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Effects of Synchronous Group Work on Learning and Community in Online Mathematics at Community Colleges

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Abstract

Online learning plays an increasingly important role in community college education. However, evidence has shown that online learning can be a challenge, especially in mathematics, and students are not performing as well in online classes as they are in face-to-face formats. In addition, the online environment can be isolating and lonely, with little opportunity for interaction and group work with fellow students. With the increased demand for online mathematics courses at the community college level, it has become imperative that two-year colleges find ways to increase online student success while simultaneously fostering interaction, collaboration and community. This study focused on embedding required synchronous group work sessions using rich web conferencing tools as a potential solution to these challenges. Through a quasi-experimental design, the goal was to determine the impact of these synchronous group work sessions on students' academic success and sense of community in online college-level mathematics courses at two Midwestern community colleges. It was hypothesized that these synchronous sessions would increase academic success as well as build classroom community. However, results could not confirm an increase in formative scores, summative scores or sense of community due to the synchronous group work sessions. Only College Algebra experienced a medium effect of treatment on sense of community. Small positive correlations were shown to exist between sense of community and formative and summative scores. Further research with larger samples and greater control of preexisting student differences could clarify the potential of synchronous group work in the online college-level mathematics course.

Chapter I - Introduction

Background of the Problem

Community colleges offer hope for students struggling for access to higher education. Many students entering two-year colleges are frequently underprepared and overextended. They typically have increased risk factors for success, greater responsibilities at home and outside of school, and more devastating opportunity costs if the college experience fails. Community colleges know their audience and recognize the flexibility and opportunity that online learning can provide for students who may not otherwise be able to take college courses. However, the online environment can be lonely, isolating and a challenge. Moreover, online instructors often face numerous obstacles including a lack of training in online teaching, constantly changing technology that still leaves much to be desired, and an inability to replicate the engagement and sense of community of a face-to-face classroom. It is not surprising that success rates in online classes are falling short of their face-to-face equivalents. We have a responsibility as faculty, administrators, and institutions to find strategies that not only increase student success but simultaneously foster interaction, collaboration and community. Our students face enough barriers to success, so it is critical that we find ways to not be part of the problem.

Over 5.8 million students attend public community colleges, comprising 35% of total undergraduate enrollments (U.S. Department of Education, 2017e). Community colleges serve a wide variety of students due to an access-oriented mission. Compared with public four-year institutions, two-year college students are more likely to be 25 or older, attend school part-time, and be students of color (U.S. Department of Education, 2017b, c, d). As open access institutions, community colleges have minimal, if any, selective admission requirements. The majority of students entering community college are academically underprepared in math or English (Attewell, Lavin, Domina, & Levey, 2006; Bailey, Jeong, & Cho, 2010), and these students often must take at least one remedial math or English course in college (U.S. Department of Education, 2017g). More students require developmental math than reading or writing (Attewell et al., 2006, Bailey et al., 2010). In 2016-17, 99% of public two-year institutions offered remedial services compared to only 75.2% of public four-year schools (U.S. Department of Education, 2017h). Community college students also face more obstacles and risks than their four-year institution peers. According to the American Association of Community Colleges (AACC; 2017), four-year institutions enrolled 70% of all undergraduates who have zero risk factors, while community colleges enrolled only 16% of students with zero risk factors. These risk factors, such as delaying college enrollment, having dependents, or working while in school, have been shown to impact persistence and completion (AACC, 2017). Furthermore, community colleges enroll a large and disproportionate share of students with risk factors, with the proportion of students served by community colleges increasing as the number of risk factors increases. For example, 53% of students with 5-7 risk factors were enrolled at community colleges compared to 20% at four-year institutions (AACC, 2017). It is clear that community colleges have a varied and challenged student population.

Community college plays a crucial role for many students, particularly those considered nontraditional, by providing access to a postsecondary education that might not otherwise be available. Despite low tuition, community college students still pay a hefty price for the opportunity to attend. Tuition and fees, textbooks, housing, food and transportation costs often require student loans and/or working long hours to pay the bills. There can be psychological and opportunity costs associated with attending college besides the financial outlay. Withdrawing or failing classes, especially math courses which are notorious barriers for students, can have a significant impact on students' lives, finances, motivation, confidence and future. Therefore, it is necessary that community colleges and instructors investigate ways to support and improve student success.

The use of the online format for college coursework has become increasingly popular, especially at the community college level. The U.S. Department of Education (2017e) reported that nearly a third of all students were taking some of their courses at a distance in Fall 2016. In 2015-16, 44.5% of students at public two-year institutions took online classes compared to 33.9% in 2011-12 (U.S. Department of Education, 2017f). Distance education enrollments have continued to grow despite a recent decline in overall undergraduate enrollments (U.S. Department of Education, 2017a, f). In general, community colleges offer more online courses than four-year institutions because they cater to a student population that needs flexibility as students work full- or part-time or raise a family.

Unfortunately, there is growing evidence that community college students do not perform as well in online courses compared to face-to-face classes (Amparo, Smith & Friedman, 2018; Jaggars, 2012; Xu & Jaggars, 2011a, 2011b, 2013). The Community College Research Center (CCRC) conducted rigorous large-scale studies of over 40,000 community and technical college students in Washington State and nearly 24,000 Virginia community college students (Jaggars & Xu, 2010; Xu & Jaggars, 2013). These two broad studies found that completion rates in online courses ranged from 8 to 13 percentage points lower compared to face-to-face courses (Jaggars & Xu, 2010; Xu & Jaggars, 2011b). Additionally, Hart, Friedmann and Hill (2016) used data from over 3 million enrollments in the California community college system. Students were 8.4% less likely to complete, and 14.5% less likely to pass, their online courses compared to their face-to-face courses (Hart et al., 2016).

Focusing specifically on online mathematics courses at the community college level, the situation is even more discouraging. Hart et al. (2016) found a significant performance gap between online and face-to-face mathematics courses compared to other subjects. Nationally low success rates in math at the community college level, compounded with an online format, result in even lower completion rates for online mathematics courses. Moreover, many students enter community college unprepared to take college-level mathematics courses right away. As a result, students may be placed into developmental math courses that often require a progression of several developmental classes before the student can even reach a college-level math course. According to Jaggars and Xu (2010), the completion rate for online developmental math was more than 20% lower among students who had taken at least one online course, slowing even further student progress toward a degree.

In a large scale study analyzing 122 community college course sections, Wladis, Hachey and Conway (2014) found that attrition rates in online science, technology, engineering and mathematics (STEM) courses were higher than those in non-STEM courses. In particular, lower level STEM courses taken as electives or distributional requirements had higher attrition rates (Wladis et al., 2014). This research study was conducted in an online Introduction to Statistics class and a College Algebra course. Both are popular introductory level courses that meet distributional requirements for many students, suggesting the potential for higher rates of student withdrawal and attrition. More recently, however, Wladis, Conway and Hachey (2017) found that although lower level courses had lower completion rates than upper level courses in general, the lower level online courses actually had higher course completion rates than face-to-face.

It is evident that the online course format, whether in mathematics or any subject, poses many challenges. There are many factors that make success in an online course difficult. To better understand online learning and teaching in community college settings, it is important to define the different types of online interaction that are possible and explore several relevant online learning theories. The goal is to develop a framework that might explain the difficulties behind online learning and offer some potential strategies for overcoming these obstacles.

Asynchronous versus synchronous. The majority of online courses were historically taught in an asynchronous format (Parsad & Lewis, 2008) where instructor and student interactions are not typically conducted in real-time. In the asynchronous format, students are able to work at their own pace by watching pre-recorded video lectures and interacting on their own schedule via the discussion board or email. Research is now beginning to investigate online courses that contain some sort of synchronous component, where instructors and students may not meet in the same place, but they access some portion of the course simultaneously at predetermined times and there is live interaction between the students and their instructor (Falloon, 2011).

However, little research addresses the combination of both asynchronous and synchronous components within the same online course (Lamb, 2018; Lowenthal, Dunlap & Snelson, 2017; Strømsø, Grøttum, & Lycke, 2007).

The asynchronous format provides learners with independence, flexibility and choice in how to study. It also offers several benefits over synchronous learning. Because asynchronous learning is “anytime, anywhere,” it provides students the flexibility to login and work as their schedule permits, whereas synchronous learning may be a challenge for students who have time constraints and are not able to attend synchronous sessions at prescribed times (Falloon, 2011). Hrastinksi (2008) also found that asynchronous interaction is best for allowing time for student reflection, such as, in responding to complex ideas on a discussion board.

Synchronous communication tools, however, allow more opportunities for online learning to resemble face-to-face learning and provide much needed real-time interaction to an asynchronous online course. According to Park and Bonk (2007), the major benefits of a synchronous virtual classroom include “providing immediate feedback to students, encouraging the exchange of multiple perspectives, enhancing dynamic interactions among participants, strengthening social presence, fostering the exchange of emotional support, and supplying verbal elements” (p. 314). Synchronous communication helped reduce the sense of isolation many feel when learning online (Falloon, 2011; Park & Bonk, 2007). Synchronous communication also increased student participation, confidence, motivation and social interaction (McBrien, Jones & Cheng, 2009; Hrastinksi, 2008).

The research shows that both asynchronous and synchronous interactions have benefits within the online learning environment and play a role in connecting students, learning content and providing satisfaction in the online classroom. What remains to be seen is how best to add synchronous components to an asynchronous online course in order to increase student learning and community.

Transactional distance theory. Moore (1993) defined transactional distance as the physical separation between the student and instructor in an online course which can contribute to psychological and communication gaps leading to misunderstanding and feelings of isolation. The three main constructs of transactional distance include: (1) dialogue between the instructor and the learner; (2) the rigidity or flexibility of course structure; and (3) learner autonomy, the amount of control that the learner exerts during the learning process (Moore, 1993). In transactional distance theory, "distance is not determined by geography but by the relationship between dialogue and structure with learner autonomy taken into account in varying degrees" (Gunawardena & McIsaac, 2004, p. 361). The more transactional distance that exists, the greater the responsibility that is placed on the student. According to Moore (2012), courses with greater dialogue and less structure will have less transactional distance, while less dialogue and more structure result in more distance. However, Huang, Chandra, DePaolo, and Simmons (2016) argued that higher course structure, like that supported by web-based learning environments, results in lower transactional distance. Furthermore, the combination of high structure and high dialogue was the most effective format for reducing transactional distance (Huang et al., 2016).

Media richness theory, media naturalness and social presence. Daft and Lengel (1984) developed media richness theory, asserting that communication media has varying degrees of richness. Rich media are able to mimic face-to-face communication by conveying body and language cues. They are more effective due to their potential for reducing ambiguity and misunderstanding more quickly. In media naturalness theory, information is conveyed through facial expressions, body language, and speech, using collocation and synchronicity (Kock, 2005). According to Tan, Tan and Teo (2012), using media that lacks naturalness can make it more difficult to communicate, share gestures, and express personality resulting in online communication that is more cognitively taxing and ambiguous. In social presence theory, Short, Williams and Christie (1976) defined social presence as a perceived attribute that represents the ability of a communication medium to convey the physical presence and non-verbal and social cues of the participants. These days, synchronous interactions are becoming more common due to the availability of rich media tools like web conferencing. Two-way web conferencing allows audio and visual cues from both the instructor and students, while one-way web conferencing allows shared audio but only instructor video. According to Weiser, Blau and Eshet-Alkalai (2018), one-way web conferencing communication enables students to remain invisible to the instructor and fellow students, while two-way web conferencing conveys some non-verbal social communication cues and prevents visual anonymity. Thus, it helps to foster social presence (Peacock et al., 2012). However, one-way web conferencing (the less natural media) was shown to improve the cognitive aspect of perceived learning despite the weakened social and emotional aspects (Blau, Weiser, & Eshet-Alkalai, 2017). Since synchronous media appears to be richer and more natural than asynchronous communication (Park & Bonk, 2007), their use begs the study of utilizing appropriate synchronous tools to facilitate natural communication that will support online student learning.

Community of inquiry framework. The community of inquiry (CoI) theoretical framework is potentially a useful model to consider for this study. The CoI framework depicts how the instructional, social and cognitive processes central to online learning interact (Garrison, Anderson & Archer, 2000). According to the CoI framework, effective learning occurs when teaching presence, social presence and cognitive presence interact and support each other. If strategies can be found to increase teaching, social and cognitive presence, this could in turn decrease transactional distance while also creating a community of inquiry among online learners. The CCRC studies revealed that it was necessary for online instructors to actively and visibly engage with their students, maybe even more so than in a face-to-face class (Jaggars & Xu, 2010; Xu & Jaggars, 2013). Online interaction and group work are examples of using teaching presence, dialogue and structure to increase engagement of students with each other and the content while building a sense of community. Implementing these strategies may require a blend of asynchronous and synchronous communication technologies in the online classroom.

Connectivism. The theory of connectivism is a relatively new learning theory that emphasizes building communities of learners through technology. Connectivism is a theoretical framework that regards learning as a network phenomenon (Siemens, 2005). The connectivist model proposes that learning occurs when learners make connections between ideas within their own personal learning communities (Dunaway, 2011). These learning communities, described as nodes, are constructed from diverse information resources, make use of a variety of Web 2.0 technologies and form large networks (Dunaway, 2011). Nodes can be libraries, websites, blogs or any other sources of information (Goldie, 2016). Networks comprise two or more nodes which link together and share resources. Successful networks value diversity, autonomy, openness and connectivity (Downes, 2005). Being able to filter out extraneous information and focus on the most current information is considered an important skill that contributes to learning (Goldie, 2016). The learning process is also considered to be cyclical as learners cycle through the process of connecting to their network to share and seek information, modify their beliefs based on new information, then reconnect to share and seek again.

Connectivism has not been fully accepted as a new learning theory (Verhagen, 2006; Kop & Hill, 2008; Bell, 2011), and its implementation in massive open online courses (MOOCs) remains under scrutiny. While offering open access to new information and knowledge, MOOCs require self-motivated, autonomous learners to navigate the network and make connections (Mackness, Mak and Williams, 2010). However, most learners are not autonomous and require guidance through the learning process. Connectivism promotes discussion, variety of perspectives and group collaboration (Rank, 2018), but MOOCs potentially lack the teaching presence needed to help students reach deep and meaningful learning.

Online interaction. An online classroom can be a lonely place. Online students often feel isolated and alone. The primary complaint of online students enrolled in four high-risk courses at a community college was a sense of isolation (Bambara, Harbour, Davies & Athey, 2009). Students also perceived a lack of interaction with each other. In interviews with online community college students, Jaggars (2014a) found that almost all students commented that student-instructor interaction was more distant, and less personal and immediate. Learning content by watching recorded video lectures, reading the textbook or completing online assignments without other students or the instructor nearby can make students feel as if they were teaching themselves (Bambara et al., 2009; Jaggars, 2014a). One student described her sense of isolation by saying, "I thought that it was a lot of teaching myself…I was by myself a lot. I remember feeling left out" (Bambara et al., 2009, p. 224). Therefore, it is important for instructors to make students feel that they care and are actively interested and involved in their learning (Jaggars & Xu, 2013). The only way for online instructors to do this is through online interaction with students. In an asynchronous classroom, the instructor and students do not primarily share real-time interactions. Thus, online interaction is often accomplished through discussion board posts, grading feedback, online office hours, emails and announcements. In a synchronous online format, however, instructors and students can meet online in real-time. Synchronous communication via chats or web conferencing can be used to give immediate feedback, correct misunderstandings, guide group work, clarify instructions, and give support. Student interviews have shown that online students significantly value interactions with their instructor (Bork & Rucks-Ahidiana, 2013; Jaggars, 2014a), but find it difficult to connect with their instructor (Jaggars & Xu, 2013). Jaggars and Xu (2013) reported that greater levels of interpersonal interaction correlated with better online student performance, all the more reason to increase opportunities for greater student-instructor and student-student interaction in an online class.

Sense of community. A sense of community is the feeling of belonging to a group, the sense that students matter to each other and that their needs are being met through the support of the group. In online learning communities, students work together using technology to complete tasks, achieve common goals and construct knowledge. Baturay (2011) and Liu, Magjuka, Bonk and Lee (2007) affirmed that sense of community is positively related to perceived learning, course satisfaction and learner engagement. Thus, community may enhance learning. Rovai (2002a) suggested that instructors must enhance social presence in order to nurture and support a sense of community in the online classroom. Research has shown that participation in group discussions and group work activities were key to developing and sustaining a sense of community (Oliphant & Branch-Mueller, 2016). He and Huang (2017) discovered that synchronous Google Hangouts used in combination with asynchronous tools enhanced overall satisfaction with student online teamwork and helped to develop a sense of community. It appears that quality interaction, possibly through group activities, goes hand-in-hand with creating a sense of community in the online classroom.

Online group work. Online group work is one way of incorporating meaningful interaction into the online classroom. Collaborative learning, of which group work is an example, has been widely researched. Studies confirm that collaborative learning supports active learning and the exchange of ideas within groups, develops critical thinking, increases motivation among group members, encourages socialization, improves attitudes towards learning, fosters mutual concern, and cultivates better race relations (Gillies & Ashman, 2003; Hassanien, 2007; Johnson & Johnson 2003; Sharan, 1980; Slavin, 1980). However, it is difficult to find research on the use and effectiveness of online group work, perhaps because implementing group work online is challenging (Gillet-Swan, 2017). The isolating effects of the online environment may make it harder to facilitate interactions and trust because students feel distant from their peer collaborators and are not able to get immediate feedback from group members (Gillet-Swan, 2017; Jaber & Kennedy, 2017). Scheduling real-time group work is also difficult. Anxiety or frustration with the technology along with the need for technology that can accommodate final group project presentations creates another obstacle. The benefits and challenges of facilitating synchronous online group work has not yet been widely studied. However, some research has reported that asynchronous group work activities can help promote trust, teamwork skills, group cohesion and cognitive processes among learners (Biasutti, 2011; Mayer, Lingle & Ussleman, 2017; Tseng & Yeh, 2013). Oyarzun, Stefaniak, Bol and Morrison (2017) demonstrated in an asynchronous online course that high levels of interactions with collaborative intent significantly affected instructor and student social presence and positively affected learner achievement and satisfaction. Palloff and Pratt (2013) and Hassanien (2007) corroborated that online group work helps reduce the feeling of isolation in an online class and promotes the development of higher order thinking skills, including reflection. Rovai (2002c) demonstrated that creating a greater sense of online community through collaborative activities leads to greater perceived cognitive learning. When students work with each other instead of alone, they experience less anxiety and find ways to communicate with their group and problem solve (Harasim, 1990). This is the goal of using a synchronous component dedicated to online group work and supervised by the instructor. Strang (2013) and Falloon (2011) showed that synchronous interaction works well for allowing group work, cooperative learning and the exchanging of ideas. Furthermore, Overbaugh and Casiello (2008), Strang (2013), and Rockinson-Szapkiw and Wendt (2015) recommended using synchronous communication for group projects because the media richness of synchronous tools promoted deeper learning and community. In a traditional face-to-face classroom, students are able to immediately ask questions to clarify concepts. In an online classroom, answers to these questions are often delayed, which can lead to a student's frustration and lack of motivation. Using a rich media tool for online group work, like web conferencing, would provide the opportunity for students to ask questions and get immediate answers from both the instructor and fellow students. These real-time interactions would promote collaboration and community while engaging students in the learning content.

Online learning plays an increasingly important role in community college education. Based on the evidence that online learning is a challenge, especially in mathematics, the question becomes how online learning can be improved at the community college level in order to reach or exceed the success of face-to-face learning. Community college students face many barriers to success so it is critical as online instructors that we find ways to not be part of the problem. This study focused on one potential solution to these challenges.

Purpose Statement

The purpose of this study was to determine the impact of synchronous group work sessions on students' academic success and sense of community in online mathematics courses at the community college level. It was anticipated that embedding a required synchronous component that utilizes group work activities into college-level online mathematics courses would increase student academic success while also improving student sense of community. Since students must earn an A, B or C to move on to the next math course, academic success is defined as earning a C (70%) or above.

Hypotheses

Research has shown that social interaction created using synchronous tools enhanced the collaborative learning process and supported students' understanding of difficult material and the application of content (Rockinson-Szapkiw, Baker, Neukrug, & Hanes, 2010). This interaction among and between students and the instructor encourages deep learning processes (Offir, Lev, & Bezalel, 2008), and as Sher (2009) demonstrated, was found to be a significant contributor of student learning. Zhao, Lei, Yan, Lai, and Tan (2005) confirmed that utilizing both synchronous and asynchronous interactions resulted in more positive outcomes than using only one type of interaction. Moreover, Mabrito (2006) reported that students perceived synchronous sessions as more productive and better for group work than asynchronous sessions. A meta-analysis by Springer, Stanne, and Donovan (1999) concluded that small-group learning was effective in developing greater academic achievement in STEM courses. Therefore, it was hypothesized that student academic success in online college-level math classes would improve when synchronous components were added to asynchronous courses in order to implement online group work.

Student academic performance was classified into two categories, formative and summative academic performance. The final course grade percentage represented the student's summative performance, while the mean grade on all homework and lab assignments represented the student's formative performance.

Hypothesis 1: It was hypothesized that student formative academic success in online college-level math courses will be greater when synchronous group work sessions are utilized.

Hypothesis 2: It was hypothesized that student summative academic success in online college-level math courses will be greater when synchronous group work sessions are utilized.

Interaction is also an essential element to the development of sense of community (Rovai, 2002a). Falloon (2011) discovered that a virtual community reduced feelings of isolation and helped build a sense of community. McInnerny and Roberts (2004) and Park and Bonk (2007) reported that in order for a sense of community to exist and productive social interaction to occur, there must be increased use of synchronous communication (in addition to asynchronous communication). Indeed, Rockinson-Szapkiw and Wendt (2015) affirmed that students who used synchronous technology established a greater community of inquiry than purely asynchronous students. Therefore, it was hypothesized that adding synchronous components to asynchronous online college-level math courses would increase student sense of community.

Hypothesis 3: It was hypothesized that student sense of community in online college-level math courses will be greater when synchronous group work sessions are utilized.

Research has confirmed positive relationships between sense of community, course satisfaction, perceived learning and learner engagement (Baturay, 2011; Liu, Magjuka, Bonk & Lee, 2007). Moreover, sense of community has been proven to be positively related to motivation (Moller et al., 2005) and achievement (Wighting, Nisvet,

& Spaulding, 2009). Therefore, it was hypothesized that sense of community and a student's formative and summative performance (academic success) were positively related.

Hypothesis 4: It was hypothesized that there is a positive correlation between sense of community and student formative performance.

Hypothesis 5: It was hypothesized that there is a positive correlation between sense of community and student summative performance.

Significance of the Research

The increase in popularity for online mathematics courses necessitates research within this content area. Recent research has shown how completion rates in online courses, and developmental and college-level online math courses in particular, are trailing far behind face-to-face completion rates (Hart et al., 2016; Jaggars & Xu, 2010; Xu & Jaggars, 2013). Given that online courses appeal to a current generation of students who need flexibility and options, it is critical that community colleges strive to find ways to make these online courses as successful as face-to-face classes. Quality interpersonal interactions between the instructor and the student are important predictors of student success, and strategies in course design that encourage and provide opportunities for these interactions are necessary. Requiring synchronous live meetings that allow for student-instructor and student-student interaction in otherwise asynchronous online courses could be a solution for increasing social interaction and building a sense of community. The incorporation of such a synchronous element may allow for group work opportunities, which can be difficult to implement in an online math classroom, and for providing real-time instruction and support at flexible, non-traditional times.

This study contributes to the research on how synchronous communication can be combined with asynchronous learning. It differs in that it addresses using a rich media tool to enable synchronous online group work. Although several studies have explored the use of web conferencing technology in the online classroom, many did not use the technology for the purpose of synchronous group work sessions. Also, the focus of much research has been the effect of synchronous communication or group work on perceived learning and satisfaction, not on actual academic success (i.e., learning outcomes or grades) or sense of community.

This study also involved a unique sample of college-level mathematics courses at two-year colleges. Most research using synchronous (and asynchronous) tools involve undergraduate and graduate students at four-year colleges and universities. Compared with public four-year institutions, two-year community college students are more likely to be nontraditional (U.S. Department of Education, 2017b, c, d). They are also typically less academically prepared in math and English (Attewell et al., 2006; Bailey et al., 2010) than those who have participated in previous research studies and potentially face more outside challenges and risk factors, like family and work responsibilities, that may compete with their time to learn (AACC, 2017).

Lastly, this study was conducted within online mathematics classrooms. Mathematics is challenging for most students when it is taught face-to-face, and even more so when taught online (Affouf & Walsh, 2007; McCabe, 2007; Mills, 2004). Compounding difficult content with a challenging course format makes it all the tougher for students to be successful. This study utilized complex synchronous technology in new ways to encourage student interaction and increase academic success and community among a unique population of community college students in online college-level mathematics courses.

Limitations

The main limitations manifest in this study relate to generalizability. The study took place in undergraduate college-level mathematics courses at two Midwestern suburban community colleges. Results were based on a small population of students from two online Statistics classes and two online College Algebra classes, with almost all of the student participants being local to the region. This population may not represent the wider population of two-year (or four-year) college students and may lack the diversity present on more urban community college campuses. Study results may also be different at more selective four-year universities. Community colleges routinely serve students with lower levels of academic preparation and achievement. These students may also be more overextended in their life, juggling school, work, and family obligations, perhaps more so than a traditional four-year college student (AACC, 2017). Students who are struggling to handle multiple responsibilities may be less likely to have time to commit to regular synchronous sessions at prescribed times. This could lead to poor attendance in the synchronous sessions (along with lower participation scores) resulting in lower academic success than those students who are not required to attend synchronous sessions at set times.

A unique limitation is the fact that mathematics has its own vocabulary and notation, which can be difficult to explain, type, and write in synchronous sessions.

Online STEM courses are complicated by discipline-specific requirements: symbolically-rich notation, complex calculations that often require solving by hand or using calculators or special software, and even scientific experiments. In addition, students often need to write out and see solutions, as opposed to just talking out loud about the problems. The whiteboard feature available with rich media tools is necessary to write out these steps and show notation since students are unable to type in mathematical symbols. This study employed shared whiteboards so that students would be able to write out and share their work. This feature may not be as necessary in other subject matters where verbal communication is sufficient to support group work and provide feedback. This aspect of written math work requires additional complex technology that may complicate the success of the synchronous sessions if technology issues are prevalent. Disciplines that don't require this need may fare better.

Finally, two different instructors participated in this study, teaching two different courses. Comparison of grades obtained by students was complicated by different learning activities, grading schemes, and assessments. Furthermore, it is well known that course design and instructor experience impact student learning, and this could not be completely controlled in this study. The directions, activities, questioning style and facilitation involved in the synchronous group work sessions was unique to each instructor and undoubtedly affected student's interactions and learning. Though this may be thought of as a limitation, it is in fact a reality of teaching and academic freedom. Any positive impact on student success or sense of community would be all the stronger and more generalizable due to the fact that the intervention was successful regardless of subject matter, course design or instructor.

Definition of Key Terms

Online learning format. A course delivered via an online learning format uses a learning management system with computer-mediated communication tools to provide students interaction with instructors, content and other students. Predominantly online courses typically do not require any face-to-face meetings except for potentially an orientation meeting on the first day and/or meetings for a midterm and final exam.

Asynchronous online format. In an asynchronous online format, instructor and student interactions are not conducted in real-time. Students access course content through a learning management system and use online communication tools at any time or in any place.

Synchronous online format. In a synchronous online format, instructors and students access some portion of the course simultaneously at prearranged times and there is real-time interaction between the instructor and students.

Developmental-level. Developmental-level courses do not typically provide college credit but are required as prerequisites to help prepare for success in college-level courses. Students may be required to take some developmental mathematics, reading and/or English courses if they do not initially place into a college-level course in that subject area.

College-level. College-level courses provide college credit if a student receives a passing grade. Students can apply credits they earn in college-level courses toward a degree.

Chapter II - Literature Review

Community colleges play a vital role in higher education. Their open admission policy, combined with low tuition and being close to home, makes them an important pathway to postsecondary education for many students, especially first-generation college students, those from low-income families, and adults returning to school for additional training or credentials (Ma & Baum, 2016). According to the National Student Clearinghouse (NSC; 2017), almost half of all students completing a degree at a four-year institution in 2015-16 had enrolled at a two-year institution at some point in the previous 10 years.

Costs of Attending Community College

According to College Board (2018), the average cost of tuition and fees for full-time public two-year in-district students was $3,440, 37% of the average price for public four-year in-state students. For community college students, tuition and fees comprise a relatively small portion of their annual expenses. Food, housing, books and supplies, transportation and other miscellaneous costs can total more than $16,000 a year (Ma & Baum, 2016). While community college students may receive grants and educational tax benefits that on average cover tuition and fees, many students must still earn or borrow funds to cover living expenses if their families cannot provide assistance (Ma & Baum, 2016). Over the past several decades, there has been a shift in financial aid from grants to loans along with steady increases in tuition; more aid has been distributed, but with an emphasis on loans rather than grants (Paulsen & St. John, 2002). Nontraditional students often have more restricted college choices because of limited financial resources or experiences, and there is an inadequacy of financial aid relative to college costs, especially for low-income students (Paulsen & St. John, 2002). Although community college students are less likely to borrow, and on average borrow less than other students, (perhaps because of the lower cost of attending community colleges), a higher percentage of these borrowers default on their federal student loans than other students (Ma & Baum, 2016).

Additional costs to college exist that may not always be considered or anticipated. While universal access to the Internet is fairly well-established, low-income households may still be at a disadvantage in terms of the technical infrastructure needed to take college classes, especially online courses. Students often need access to a computer, printer, scanner, microphone/headset, online instructional software, eBooks, and more. College computer labs can provide access during school hours, but online learning implies flexibility, with students most often studying at night and on weekends when the campus may be closed. In addition, the price of college textbooks in the U.S. has increased by more than 120% over the past fifteen years (U.S. Bureau of Labor Statistics, 2018). As a result, students' educational choices are increasingly driven by the question of whether they can afford their required course materials (Jhangiani & Jhangiani, 2017). A growing number of students are opting to do without their required textbooks (Jhangiani & Jhangiani, 2017). In a survey of 20,000 students in Florida, two-thirds responded that they had not purchased at least one of their required textbooks, with 38% indicating they earned a poor grade as a result (Florida Virtual Campus, 2016). Moreover, 48% of respondents had taken fewer courses, 26% had dropped a course, and 21% had withdrawn from a course, all reportedly due to cost. Jhangiani and Jhangiani (2017) also found that the burden of textbook costs was disproportionately carried by economically disadvantaged students, including those holding student loans and those working more hours per week.

When you add in the need to take developmental level courses because students come to college underprepared, students face significant financial and psychological costs (Bailey et al., 2010).

> While they are enrolled in remediation, students accumulate debt, spend time and money, and bear the opportunity cost of lost earnings. In some states, they deplete their eligibility for financial aid. Moreover, many students referred to developmental classes, most of whom are high school graduates, are surprised and discouraged when they learn they must delay their college education and in effect return to high school. (Bailey et al., 2010, p. 4)

This can result in frustration and cause students to give up and drop out (Deil-Amen & Rosenbaum, 2002). In addition, many students placed into developmental math have previously struggled with the subject and carry negative experiences and attitudes that can be difficult to overcome, especially when these students are faced with the barrier of multiple math classes to pass before even beginning their college pathway.

Why is Math Such a Barrier?

There have been many attempts at math reform over the years to address America's lack of math proficiency on national tests. "The new math" and the Common Core stem from the idea that the traditional way of teaching math doesn't work. Some say that the nation suffers from innumeracy – the mathematical equivalent of not being able to read (Green, 2014). Most American math classes focus only on procedures, rather than on what the procedures mean or how to apply them to new problems. "Students learn not math but … answer-getting" (Green, 2014, para. 24). Many developmental math students do not know how to study or learn math effectively, concentrating on memorizing formulas and facts, instead of understanding how to make connections between topics. Both Miles (2000) and Pang (2010) agreed that poor arithmetic skills are a much more significant problem now than they were in the past and remain a barrier for students. Green (2014) also claimed that colleges charged with training math teachers in new approaches fail to do so, perpetuating the problem for future generations of teachers and students. Teacher training is weak and infrequent, with administrators offering little support. Even textbooks receive only surface adjustments and have changed little over time (Green, 2014).

Another reason that math remains a barrier for students is the fact that most developmental and college level mathematics courses follow a linear progression (Boylan, 2011). Students need to master material from one chapter before moving on to the next. Therefore, poor attendance and misunderstandings may create gaps that hinder the mastery of content. Smith et al. (1996) found a strong relationship between attendance and grades. After missing several classes, some students fall behind, unable to catch-up and either fail or withdraw from class. Just as math curriculum has a linear structure, solving math problems also requires a logical, linear and organized method. For students who are sloppy or struggle with organization, this can represent another barrier and be detrimental to student success (Caferalla, 2014). Moreover, due to the linearity of a math sequence, "earning a C in a current algebra course most likely translates to failing the next algebra course" (Boylan, 2011, p. 21). Passing one class is not enough to guarantee future success.

The amount of time since a student has taken their last math class has a significant impact on their placement and success in math courses. If you don't use it, you lose it. In contrast, despite not having taken English and reading classes since high school, students are able to retain some of this knowledge because they continue to use these skills in everyday life. This is rarely the case for math (Boylan, 2011). Unfortunately, it is also socially acceptable to be bad at math and even fail it. When students face personal problems that require a lighter course load, they usually withdraw from math first (Boylan, 2011). Math completion becomes the first casualty because it is socially acceptable to fail. Furthermore, the cycle often repeats itself because students who retake a math course often get the same type of instruction that led to their failure in the first place (Boylan, 2011).

There has been an influx of technology into mathematics classrooms and curriculum. Some math courses have become entirely computer-based while others, even face-to-face courses, have incorporated software and online components. In fact, the American Mathematical Association of Two-Year Colleges (AMATYC; 1995) called for greater use of technology in developmental classes, reiterating this again in 2006 (AMATYC, 2006). They also stressed the need for real-life applications of mathematics. Calculators and math software enable teachers to teach more sophisticated real-life examples, as well as providing greater precision, speed and power. However, Schwartz (2007) expressed concern that developmental math students may rely too much on technology, leading to decreased proficiency in basic arithmetic skills. Faculty interviews confirmed that an excessive amount of developmental math students are dependent on a calculator (Cafarella, 2014).

Another barrier for students is the relationship between math anxiety and math performance. Math anxiety can be defined as a state of discomfort around performing mathematical tasks (Ma and Xu, 2004). For some, dealing with numbers or anything math-related elicits an emotional response that affects performance (Suárez-Pellicioni, Núñez-Peña, & Colomé, 2016). In the Program for International Student Assessment (Organisation for Economic Co-operation and Development [OECD], 2013) report, math anxiety was more prevalent than previously thought: around 30% of 15-year old students from OECD countries reported feeling helpless or nervous when solving a math problem, 33% felt tense when solving math homework, 59% were worried about the difficulty of math classes, and 43% agreed that they were not good at math. Carey, Hill, Devine and Szücs (2016) found conflicting evidence about whether math anxiety causes poor math performance or whether poor past performance causes math anxiety. Carey et al.'s (2016) literature review suggested that math anxiety affects cognitive processing, and may be caused by a deficit in numerical processing along with a genetic predisposition to deficits in math cognition. Math anxiety has also been linked to reductions in working memory, stereotype threats, and negative and intrusive thoughts (for full literature review see Carey et al., 2016). Adults with high math anxiety tend to avoid mathematical tasks and are less likely to enroll in college courses involving any mathematics (Hembree, 1990). This was supported by Bailey et al.'s (2010) findings that a majority of developmental education students who didn't complete their full sequence failed to do so because they did not enroll in their first course or a subsequent course, rather than because they failed or withdrew from any courses they attempted. Math anxiety leads to procrastination and avoidance which just leads to further mathematical deficiencies (Carey et al., 2016).

In her research on student mindset, Dweck (2008) informally noted that students are more likely to have a fixed view of math skills than of other skills. Someone with a fixed mindset about intellectual abilities believes that people have different levels of abilities and this ability can't be changed. Whereas, someone with a growth mindset believes that intellectual abilities can be developed through application, practice and instruction (Dweck, 2008). In a growth mindset, "people may differ in their current skill levels, but … everyone can improve their underlying ability" (Dweck, 2008, p. 2). Dweck (2008) cited research that mindsets can play an important role in the underachievement of women and minorities in STEM fields. Dweck (2008) argued that over the last few decades, it has become common place to try and make students feel good about themselves in math by praising their intelligence or by "relieving them of the responsibility of doing well, for example, by telling them they are not a 'math person' … [thus promoting] a fixed mindset" (p. 8). Instead, a best practice should be to praise the learning process, so that students will pursue and thrive on challenges (Dweck, 2008). Educators, parents and society must communicate the message that we value hard work and learning from mistakes.

Best Practices in Mathematics

So, what are some best practices to implement when teaching mathematics? The National Council of Teachers (NCTM) published *Principles and Standards for School Mathematics* in 2000. These ambitious goals for teaching and learning math included acquiring the skills and knowledge to solve math problems, understanding the traditional and expanded basics of math needed for a technological world, and developing reasoning skills that result in flexible and resourceful problem solving (NCTM, 2002). These NCTM standards promote teachers asking questions, building on student's thinking and exploring different solutions. The math classroom should have various mathematical and technological tools to use when appropriate, and the focus in the classroom should be on learning, understanding and doing high-quality math (NCTM, 2002). Students are encouraged to reflect on their thinking during the problem-solving process so they can apply what they've learned to new contexts (NCTM, n.d.). AMATYC (1996, 2006) also released similar mathematical content and pedagogy standards. Along with the endorsement of teaching with technology, AMATYC also advocated for interactive and collaborative learning, connecting mathematics with other experiences and disciplines, using multiple approaches and experiencing math through labs, projects and apprenticeships (AMATYC, 1996). Many of these standards align with the premise of this research study.

More recently, there has been a push to implement high impact practices in the classroom. Examples of these high impact practices include accelerated remediation, bridge programs, supplemental instruction, learning communities, co-requisite remediation, academic planning and goal setting, first year seminars, early alerts, tutoring, service learning, common intellectual experiences, collaborative assignments, undergraduate research, and capstone projects (Hatch, Crisp, & Wesley, 2016). The American Association of Colleges and Universities (AAC&U) and the Center for Community College Student Engagement (CCCSE) identify these practices as high impact or promising. Unfortunately, there is little research yet on how effective these high impact practices are, especially in the math classroom and at community colleges. However, the CCCSE has found notable differences in engagement for students participating in high impact practices (CCCSE, 2013) as well as positive relationships between high impact practices and persistence and high impact practices and successful completion of at least one developmental education or gatekeeper course (CCCSE, 2014).

Other best practices for the mathematics classroom include good communication and interaction between students and instructors. In interviews with experienced developmental math instructors from a community college, Cafarella (2014) reported that frequent email communication between instructors and online developmental math students was especially important for student success. Zavarella and Ignash (2009) suggested regular two-way interaction between the student and the institution in order to correct misunderstandings about expectations in an online developmental math course. Cafarella (2014) also noted that developmental math students need frequent reminders about due dates and tests, more than other first-year students, and that these students also need help with organizational skills. Boylan (2002) found that unstructured individual study was not a good fit for developmental students because of students' weak study skills, poor time-management skills, and underdeveloped individual learning skills. The linear progression of mathematical content and the need for logical, organized methods for solving math problems also implies the need for teaching these skills. Cafarella (2014) defined the art of organization as a best practice for developmental math students.

In Boylan's (2011) interview with Paul Nolting, an expert in developing effective student learning strategies for math success, Nolting recommended that instructors teach students math study skills as well as strategies for reducing test anxiety and increasing math self-efficacy. Developmental students in particular can benefit from manipulatives integrated into lectures, math study skills lessons, group work, web-based supports, tutoring, frequent quizzes and practice tests, and counseling referrals for anxiety and personal problems (Boylan, 2011).

Furthermore, AMATYC has strongly advocated for the use of interactive and collaborative learning (AMATYC, 1996). Cooperative learning, discovery-based learning, oral and written reports, writing in journals, open-ended projects and alternative assessments such as essay questions and portfolios are all encouraged in the math classroom (AMATYC 1995, 2006). In interviews with Cafarella (2014), faculty also emphasized the need for regular low stake assessments throughout the academic term, so that instructors can get a better sense of student comprehension before it is too late to intervene. Guidelines for pedagogy recommended decreased use of lecturing, drill and practice, rote memorization, one-step single-answer problems, and tests and final exams as sole assessments. Instead, *Crossroads in Mathematics: Standards for Introductory College Mathematics before Calculus* (AMATYC, 1996) supported using a variety of teaching strategies, incorporating technology to aid concept development, assigning multi-step, open-ended problems and providing diverse and frequent assessments in and outside of class.

Considering that negative experiences in the math classroom have been linked to the development of math anxiety, Suarez-Pellicioni et al. (2016) outlined some suggestions for teachers in the classroom. They recommended that teachers should encourage students to ask questions and make them feel comfortable, especially those who are struggling with math. It is also important to break any stereotypes that teachers may have about gender, race, and income level in math competence as well as reduce teachers' own math anxiety in order to avoid transference to students. Suarez-Pellicioni et al. (2016) reminded teachers to watch their messaging about who can do math, to highlight the importance of math, and to reiterate that working hard is the only way to succeed. This aligns with Dweck's (2008) best practice advice to praise the process and the importance of learning from your mistakes.

The evidence is clear that math presents a barrier to students, and there is little documented success for how to overcome these challenges when teaching mathematics, even when following best practices. When students fail, they face financial, psychological and opportunity costs that could potentially halt their college experience. Taking math courses online only adds to the difficulty faced by community college students. Research suggests that online learning requires greater learner autonomy. An online student needs high levels of metacognitive skills including self-regulation, self-discipline and knowing how and where to get help in order to be successful (Shea et al., 2012; Xu & Jaggars, 2014). Students in online courses also need time management skills, motivation and personal responsibility, perhaps more so than face-to-face students (Bork & Rucks-Ahidiana, 2013). Shea et al. (2012) demonstrated that student collaboration fosters these meta-cognitive, motivational and behavioral traits (which they called learning presence). This research study purposefully designed pedagogy to support communication, collaboration, and interaction in order to promote learning presence and align with some of the best practices listed above.

Online Learning

Online learning has become a popular mode of learning and instruction due to the flexibility and convenience it affords students. Distance education enrollments continue to grow, even though campus-based enrollments have declined in recent years (U.S. Department of Education, 2017a, f). Online courses typically benefit college enrollments by reaching out to a wider audience of working adults who may not normally be able to take face-to-face courses on campus. In student interviews conducted by Jaggars (2014a), almost all students reported that the flexibility of an online schedule helped them manage their busy lives. Online learning supports the access-oriented mission of community colleges.

Sadly, the research is beginning to show that community college students are not as successful in online courses compared to face-to-face classes (Jaggars, 2012; Xu & Jaggars, 2011a, 2011b, 2013). Initially, a 2009 meta-analysis by the United States Department of Education found that students in online or hybrid courses actually fared better than in traditional face-to-face formats (Means, Toyama, Murphy, Bakia, & Jones, 2009). However, many of the studies examined in the meta-analysis involved non-representative subjects and courses (e.g., subjects conducive to online learning like computer programming or courses that were short and not typically a semester long) and many of the schools involved were relatively selective universities, not community colleges that typically serve students with lower levels of academic preparation and achievement (Jaggars & Bailey, 2010). Large-scale studies conducted by the Community College Research Center (CCRC) in the Virginia and Washington State community and technical college systems confirmed that online completion rates were 8 to 13 percentage points lower than face-to-face courses (Jaggars & Xu, 2010; Xu & Jaggars, 2011b). Similarly, Hart, Friedmann and Hill (2016) corroborated that California community college system students were less likely to pass or complete their online courses.

Jaggars and Xu (2010) found that those students selecting the online version of a class tended to be stronger students, yet still struggled to pass. Some students struggled more than others. Xu and Jaggars (2013) reported that students who were male, younger, Black, low-income or had a lower prior grade point average were less successful in online courses. A similar study by Kaupp (2012) discovered that online instruction widened the Latino-White achievement gap. Unfortunately, the students who are already struggling in college are the ones who tend to fare the worst in online classes. The online format appears to be exacerbating the higher-education achievement gap. As Xu and Jaggars (2013) observed, "this is troubling from an equity perspective: If this pattern holds true across other states and educational sectors, it would imply that the continued expansion of online learning could strengthen, rather than ameliorate, educational inequity" (p. 23).

While the evidence is growing that community college students aren't doing as well in online courses as in traditional face-to-face courses, there is a bit of a paradox regarding degree completion. The broad study done in Virginia demonstrated that community college students who take online courses graduate at lower rates than students who do not (Jaggars & Xu, 2010). Jaggars and Xu (2010) also reported that students who took a higher proportion of online credits were slightly less likely to transfer to a four-year school or earn an educational award. On the contrary, Shea and Bidjerano (2014) claimed that community college students who take online courses were more likely to complete their two-year associate's degree or some sort of certification compared to students who did not take any online courses. They also found that students taking online courses were more likely to graduate, and sooner, than students who do not take any online classes. Shea and Bidjerano concluded that students may be doing worse at the course level by earning lower grades, but they were finishing at the program level. Johnson and Mejia (2014) reported that students who took at least some of their classes online were more likely to transfer to a four-year college or earn their associate's degree. One hypothesis is that those students who are passing online classes are earning credits and working their way through their course requirements. They may only be earning C's, but they are graduating, and in larger numbers, because it is often easier to enroll in an online class (Johnson & Mejia, 2014). Face-to-face classes are facing budget cuts with reduced sections and more limited scheduling options, so students may find it more difficult to find a face-to-face class that fits their schedule. The longer a student has to wait to register for a face-to-face class that fits, the less likely they are to complete and finish. If online learning does indeed boost degree completion, then it is a valuable option for students who would not normally have access to a degree. Therefore, it is worthwhile to invest resources and research into findings ways to increase the effectiveness of online courses.

Success rates specifically in online mathematics courses at the community college level are notably poor. According to Hart et al. (2016), a 20-30% higher performance gap existed between online and face-to-face mathematics courses compared to other subjects. Many students are unprepared to take college-level mathematics courses upon entering community college and are required to take a progression of developmental courses before reaching college-level math. Bailey et al. (2010) used the same data set as the CCRC studies and found that 59% of the community college students in the study were referred to developmental math. Jaggars and Xu (2010) discovered that the completion rate for these online developmental math courses was more than 20% lower among students who had taken at least one online course. Jaggars and Xu also reported that only 20% of students referred to developmental math courses continued on to pass the appropriate entry-level or "gatekeeper" college math course. Thomas (2016) used a large data set from three Texas community colleges and also confirmed that online developmental math students were less successful than those in the face-to-face format. Surprisingly, however, students who enrolled in developmental math online had higher grades in the subsequent college-level math course than those students who took their developmental math face-to-face (Thomas, 2016).

Unfortunately, the majority of community college students who get referred to developmental education do not end up completing their remedial requirements (Bailey et al., 2010). Nationally low success rates in mathematics at the community college level, combined with poor online success, hinder academic momentum resulting in lower completion and retention rates. Attewell et al. (2006) found that only 28% of recent high school graduates who entered a community college and took at least one developmental (math or English) course went on to earn any degree or certificate within 8.5 years. Efforts to improve developmental education in recent years has focused on accelerating the developmental pathway to college-level courses and improving assessment practices using more appropriate, multiple-measures placement methods (Bailey & Jaggars, 2016). Other interventions include adding self-regulating learning tools to mathematics classes

(Chatteiner, 2016), embedding group work and learning how to learn strategies into courses (Lovell & Elakovich, 2018), allowing students to enroll directly into introductory college-level courses while co-enrolling in a co-requisite support course to help fill gaps in students' knowledge (Edgecombe & Bickerstaff, 2018), and tailoring curriculum and new math pathways to better meet the needs of students, especially those not entering STEM fields (Bailey & Jaggars, 2016). Unfortunately, there is growing evidence that most reforms focused on developmental education do not create significantly higher completion rates (Edgecombe, 2016; Edgecombe, Cormier, Bickerstaff, & Barragan, 2013). Edgecombe and Bickerstaff (2018) argued that it is necessary to rethink how we address academic underpreparedness, even for those students deemed college-ready. Their suggestions included structuring remediation in ways that build academic momentum, repositioning academic supports closer to the classroom for all courses, and attending to psychosocial needs by building academic confidence and a sense of belonging (Edgcombe & Bickerstaff, 2018). It is in this last domain that the intervention proposed in this research study could help make a difference. Synchronous group work sessions may have the potential to motivate all levels of students to make connections, develop a sense of community, and build peer and instructor support all while increasing learning, confidence, and engagement, regardless of developmental status or not.

Asynchronous versus Synchronous

Distance education has evolved from a one-dimensional mode of learning where students independently interacted with content to a multidimensional experience where students interact with other students, content and the instructor. Most online courses are taught asynchronously, where student and teacher interactions do not occur at the same time (Parsad & Lewis, 2008). With the advent of new technology, broader bandwidth, and greater accessibility, synchronous communication is slowly being incorporated into the online classroom. Synchronous communication involves real-time interaction between students and teachers. How best to integrate synchronous components into asynchronous online courses is still in question.

The "anytime, anywhere" format of asynchronous online learning allows for learner independence, flexibility and choice whereas synchronous learning, with prescribed meeting times, may present a challenge to student schedules (Falloon, 2011). Besides flexibility, asynchronous learning has been shown to offer other benefits over synchronous learning, including increased time for student reflection on discussion boards (Hrastinski, 2008). Mabrito (2006) observed that while synchronous interactions generated more conversation, asynchronous interactions were more focused on content and were more effective in helping students complete their assignments. Duncan, Kenworthy, and McNamara (2012) showed that student's engagement in asynchronous discussion boards had a positive effect on both the final exam and overall course grades.

Synchronous communication tools, however, provide real-time interaction and allow online learning to simulate face-to-face learning. Live synchronous sessions support both intellectual and emotional interaction through "simultaneous, many-to-many contact that helps stave off feelings of isolation" (Haythornwaite, Kazmer, Robins, & Shoemaker, 2000, p. 48). Additional benefits of the synchronous virtual classroom include providing immediate feedback, interaction, support and social presence (Park & Bonk, 2007). McBrien, et al. (2009) demonstrated that students felt more connected in courses with synchronous interaction. However, technological issues with the synchronous component caused some dissatisfaction. Chou (2002) found more interpersonal connections were made using synchronous communication. Chou also observed that asynchronous communication tended to be more one-sided, expressing opinions rather than challenging or exchanging views, while synchronous communication allowed for more questions and answers and engaged discussions. Synchronous online interactions can also empower shy students, giving them confidence to participate more than they typically would in a face-to-face environment (McBrien et al., 2009). Synchronous communication has also been shown to increase student participation, motivation and social interaction (McBrien et al., 2009; Hrastinksi, 2008).

The evidence suggests that both asynchronous and synchronous interactions have benefits in the online learning environment. Research has shown that asynchronous interactions allow students more time to reflect on complex ideas and engage with content more deeply (Hrastinksi, 2008; Mabrito, 2006), while synchronous interactions provide more instantaneous feedback, allow for direct, immediate correction of misunderstandings and help students feel more engaged in the online learning experience (Park & Bonk, 2007). The immediacy provided by web conferencing along with visual and audio communication help build and maintain social presence (Jaber & Kennedy, 2017; Peacock et al., 2012). Synchronous communication has also been shown to increase student satisfaction and foster sense of community (He & Huang, 2017; Mayer et al., 2017) while also leading to higher levels of critical thinking (Molnar & Kearny, 2017). Stein, Wanstreet and Calvin (2009) showed that instruction that combines face-to-face and online learning can make learning less isolating and may reduce anxiety about learning activities. Synchronous components added to a primarily asynchronous online course may add that face-to-face feeling that will help reduce distance, anxiety and misunderstandings. Moreover, Duncan et al. (2012) found that using both asynchronous and synchronous engagement positively impacted overall course grades. Ligorio (2001) suggested that integrating both asynchronous and synchronous online communication causes mutual enrichment with successful completion of course requirements, more so than if using one mode alone. Giesbers, Rienties, Tempelaar, and Gijselaers (2013) also showed that participation in synchronous communication positively impacted participation in asynchronous communication, hence adding synchronous components to an asynchronous online course will increase overall engagement throughout all parts of the course, and possibly enhance learning. Research shows that both asynchronous and synchronous formats play a role in connecting students, learning content and providing satisfaction in the online classroom.

Synchronous learning systems. Online synchronous learning is similar to a face-to-face classroom in several ways. Both physical and virtual classrooms allow for sense of community, immediate feedback, and interactions between students and with the instructor (Schullo et al., 2007). Collis (1996) also identified advantages to using synchronous systems in online classrooms including the ability to foster group awareness, group decision-making and community. In addition, the real-time interaction and instant feedback helps motivate students. In scheduled synchronous sessions, the instructor and classmates are able to provide motivation and encouragement to participate, which can lead to higher retention and success (Schullo et al., 2007). Synchronous systems also give instructors additional opportunities to assess student’s knowledge and adjust course material accordingly.

There are challenges associated with using synchronous systems in the online classroom. Both students and instructors must be comfortable and competent with the synchronous technology and environment. Technical issues can result in frustration and lack of motivation, as well as increased transactional distance (Falloon, 2011). Access to technology support is necessary along with the correct technical requirements, like appropriate bandwidth to access videos and synchronous tools. Moreover, synchronous systems inherently require scheduled meeting times, which may not be convenient for all online learners. Despite these disadvantages, synchronous technologies have proven to be valuable to online learning.

Web conferencing systems can provide synchronous teaching and learning tools to the online classroom. Finkelstein (2006) listed the typical features of these virtual classroom systems and they are still relevant today.

> These features include real-time voice and visual contact between all participants; shared whiteboard; integrated area for the projection of slides or other visuals; capacity for text-based interaction, including side conversations or note-passing; means for learners to indicate that they have questions or are confused; and tools for assessing current moods, opinions, and comprehension, as well as for soliciting questions or feedback, and the ability to gauge virtual body language, or a sense of how engaged learners are in the activity at hand. (Finkelstein, 2006, p. 58)

In a comparison of two common online synchronous learning solutions, Schullo et al. (2007) identified several pros and cons of each system. Some of the cons of these virtual classroom systems (complicated interface, no breakout rooms) have since been updated and rectified since publication of Schullo et al.'s study, while all of the positive aspects remain, including two-way video, multiple speakers allowed, social presence more easily achieved through multiple windows, variety of presentation options through pod infrastructure, and compatibility for both PC and Mac. The breakout room feature provides a safe and confidential space for small groups to share ideas and work together (Cornelius & Gordon, 2013). Those who may feel uncomfortable participating in a large group may be more likely to engage with peers in small groups. Using these breakout rooms for small group work can encourage more student interaction, increasing social presence. In addition, students placed into smaller breakout rooms can become more motivated, and instructors can also monitor and engage with students at a more personalized level (Wang & Hsu, 2008). Relative to other forms of electronic media (e.g., email, telephone, chat), web conferencing supports faster feedback, more personal connections and a greater variety of information cues. Therefore, from a media richness perspective, synchronous use of web conferencing presents the richest communication environment, other than face-to-face, for supporting cooperative group interactions (Alavi, Wheeler, & Valacich, 1995). Synchronous learning systems offer instructors and students the potential for meaningful real-time communication. Web conferencing has the power to increase two-way interaction, and therefore increase dialogue, more than just asynchronous communication alone. However, limited research is available regarding how instructors use synchronous web conferencing technology to implement online group work, increase academic success or to build a sense of community.

Transactional Distance Theory

In any discussion of online learning, it is necessary to consider the seminal work of Michael Moore in the early 1970s (Moore, 1972). Transactional distance theory refers to the "distance of understandings and perceptions, caused in part by the geographic distance that has to be overcome by teachers, learners and educational organizations if effective, deliberate, planned learning is to occur" (Moore, 1991, para. 4). The theory holds that psychological and communication gaps exist due to the separation between a student and instructor in an online course, and this can lead to misunderstanding and feelings of isolation (Moore, 1993). Therefore, it is transactional rather than physical distance which impacts learning. The three main constructs of transactional distance include: (1) dialogue between the instructor and the learner; (2) the rigidity or flexibility of course structure; and (3) learner autonomy, the amount of control that the learner exerts during the learning process (Moore, 1993). The more transactional distance that exists, the greater autonomy required by the student. Dialogue involves all forms of interaction and is the primary tool used to reduce the chances for misunderstandings. Frequency of dialogue is not as important as quality and the degree to which it can resolve learning issues that an online student may be experiencing (Moore, 1993). Course structure encompasses many elements such as course design and delivery, learning activities, assessments, instructional materials, and technology. Moore's course structure construct relates to the amount of flexibility inherent in a course to allow students control over their learning pathway as well as the extent to which the course can accommodate individual learning needs. Learner autonomy is equivalent to student selfdirection. It represents the capacity for self-management permitted by an online course or program.

Transactional distance theory asserts that an inverse relationship exists between dialogue and course structure and that transactional distance is measured on a continuum of these two factors. Greater interaction and less structure results in less transactional distance, while less interaction and more structure results in more distance (Moore, 2012). Being self-directed, autonomous learners are better able to handle more structure, while less autonomous learners need more dialogue (Dron, Seidel, & Litten, 2004). It is generally agreed that when dialogue increases, transactional distance decreases (Benson & Samarawickrema, 2009; Moore, 1993) and that the greater the transactional distance, the more autonomous learners must be (Moore, 1993; Moore & Kearsley, 2005). However, there are mixed findings on the relationship between course structure and transactional distance. Falloon (2011) found that a rigid course structure may diminish the quality of dialogue and reduce the sense of learner autonomy, and consequently increase perceptions of transactional distance. However, if course structure drops too low, transactional distance can actually increase because students may feel confused and frustrated. Dron et al. (2004) showed that increased dialogue reduces transactional distance, while structure alone can increase distance. However, Chen and Willits (1998) took issue with Moore's theory suggesting that structure may not lead to misunderstandings or communication gaps, rather strong course design and delivery help facilitate understanding between teachers and students, thereby decreasing transactional distance, not raising it. Huang et al. (2016) confirmed that high structure and high dialogue can exist simultaneously using both synchronous and asynchronous communication and that this combination was the most effective format to reduce transactional distance. In particular, students who used synchronous communication perceived lower transactional distance than students who used asynchronous communication alone (Huang et al., 2016). McBrien, Jones and Cheng (2009) corroborated that students felt more connected and experienced less transactional distance in courses with synchronous interaction. However, technological issues with the synchronous component caused some dissatisfaction, and therefore increased transactional distance. Combined, these studies suggest the importance of dialogue and structure. Using synchronous technology to support real-time discussions and collaboration could increase dialogue, decrease transactional distance, and therefore, encourage student success.

Transactional distance was originally a model for online learning experiences with one-way interactions, but the introduction of interactive technology may require an adjustment of this theory in order to accommodate more multi-interactive and collaborative learning environments (Falloon, 2011; Garrison, 2000; Stein, Wanstreet & Calvin, 2009). According to Huang et al. (2016), the richer the instructional media, the lower the transactional distance. Falloon (2011) demonstrated the complex relationship that exists between the three factors of Moore's theory and how virtual classrooms can have both positive effects (increased dialogue) and negative effects (decreased learner autonomy). The impact of external structural factors such as technical issues related to access and quality of broadband, adequate computer equipment and student technical competence all had an adverse effect on student engagement and dialogue. Falloon advocated for including in transactional distance theory the external course structural factors that arise with the advent of more complex technologies in the online classroom.

Additionally, new complex technology provides greater opportunities for online group work. Jung (2001) proposed that online learning requires not only learner autonomy but also learner collaboration. Huang et al. (2016) agreed that required participation in small group discussions or class discussions resulted in lower transactional distance. While Moore's theory still contains some uncertainties, he attempted to extend the pedagogical perspective of distance learning to include the teaching-learning transaction. In Garrison's (2000) article on the theoretical challenges for distance education in the 21st century, he identified the need to focus the study of distance education on "real, sustained communication as well as emerging communications technology to support sustained communication anytime, anywhere" (p. 2). He added that new technologies allow asynchronous and synchronous communities of inquiry, therefore current theories need to adapt to the new realities of greater communication and collaborative experiences.

Media Richness, Media Naturalness and Social Presence Theory

Media richness theory, originally proposed by Daft and Lengel (1984), hypothesized that communication media has varying degrees of richness. Rich media support communication through a variety of ways, including providing instant feedback and the ability to convey cues such as body language, personality traits and tone of voice. It offers more effective communication because it has the potential for reducing ambiguity and misunderstanding more quickly. Similar to media richness theory is media naturalness theory. Information is conveyed through facial expressions, body language, and speech, using collocation and synchronicity (Kock, 2005). Both theories assume that the face-to-face medium is the richest and most natural of all (Daft & Lengel, 1984; Kock, 2005). Communication will be clearer the more similar it is to face-to-face communication (Trevino, Lengel & Daft, 1987). According to Tan et al. (2012), learners need regular access to rich media that mimics natural communication in order to avoid ambiguity. Communication with a high degree of naturalness can encourage more effective communication, which may lead to better teacher and student interactions (Weiser et al., 2018). However, Weiser et al. (2018) found that the type of interaction between students and the instructor had greater effect than the impact of medium naturalness. In Weiser et al.'s (2018) study, participation was found to be much higher and more frequent when the instructor explicitly engaged students by asking questions and encouraging participation. This emphasizes the pivotal role of the instructor in facilitating interaction and promoting participation in the learning process (Garrison & Cleveland-Innes, 2005), and suggests that teaching presence can overcome deficiencies in the communication media.

In the 1980s, most researchers concluded that computer-mediated communication (at the time, email) was inherently antisocial and impersonal because nonverbal and relational cues were filtered out (Sproull & Kiesler, 1986; Walther, 1996). During the 1990s, as people gained more experience using text-based communication, researchers argued that given enough time, people could find ways to socially interact, even with text-based communication (Carlson & Zmud, 1999; Gunwardena, 1995; Gunwardena & Zittle, 1997; Kock, 1998; Walther, 1996). Current web conferencing technology allows fewer cues to be filtered out, so it promises to allow more social and personal interaction.

However, in the online classroom setting of this study, students had restricted time to work in online groups (only one hour per week). This potentially made it more difficult to build group solidarity, reach decisions and maximize productivity, hence the synchronous group work sessions and the synchronous communication media used may appear ineffective.

Social presence theory (Short, Williams & Christie, 1976) is also related to media richness theory. It is a perceived attribute that represents the ability of a communication medium to convey the physical presence and non-verbal and social cues of the participants (Short et al, 1976). Both the characteristics of the medium and the user's perception of the medium determine the degree of social presence (Tu, 2000). Rice (1993) identified the common underlying principle between media richness and social presence:

> a good match between the characteristics of a medium (such as high in social presence or media richness) and one's communication activities (such as socioemotional activities like getting to know someone, or equivocal tasks like strategic decision-making) will lead to "better" (more effective, satisfying, etc.) performance. (p. 453)

Sproull and Kiesler (1986) claimed that computer-mediated communication reduces social context cues which inhibits interpersonal impressions. According to this perspective, computer-mediated communication will always be impersonal because it always filters out and restricts social cues. However, with the development of more synchronous technology that allows audio and video sharing capabilities, fewer cues get filtered out, possibly providing more social presence. It has been shown that synchronous technologies in online courses promote clearer communication, develop social presence and sense of community, reduce feelings of isolation, and boost confidence (Hrastinksi, 2008; Rockinson-Szapkiw, Baker, Neukrug & Hanes, 2010; Wang & Chen, 2007). These findings support media richness and social presence theory, that richer media leads to better communication with additional benefits as well.

Media richness, naturalness and social presence become even more significant when attempting to use computer-mediated communication for online group work. Online group work tends to be viewed negatively by students compared to face-to-face group work (Smith et al., 2011). Many factors influence these negative attitudes including the expectation that online courses require only independent learning (Piezon & Ferree, 2008; Smith et al., 2011). Online group work faces unique challenges when attempting to communicate with a group using only asynchronous communication. Lack of verbal cues and immediate feedback often lead to miscommunication (Smith et al., 2011). Since synchronous communication is richer and more natural than asynchronous communication, it has the potential to better facilitate natural communication that supports online collaboration and student learning. However, one can't assume that interaction will take place just because technology makes it possible (Krejins, Kirschner, & Jochems, 2003). This is where pedagogy, course design and teaching presence are necessary to impact interactivity.

Community of Inquiry Framework

The community of inquiry (CoI; Garrison, Anderson & Archer, 2000) theoretical framework aligns well with the premise of this study. Many distance learning theories focus on structural and technological issues rather than on pedagogy. The community of inquiry framework (Garrison et al., 2000), however, incorporates social-constructivist approaches to teaching and learning in the online environment. The CoI framework illustrates how the instructional, social and cognitive processes central to online learning interact (Garrison et al., 2000). In the CoI framework, effective learning occurs when three presences interact. These three presences are: (a) *teaching presence*, defined as the design and facilitation of the online classroom; (b) *social presence*, characterized by a supportive collegial online environment; and (c) *cognitive presence*, which is the degree to which learners construct their own understanding through critical thinking and reflection (Shea et. al, 2014, p. 10). Through the facilitation of these three presences, a CoI is theorized to promote higher-order thinking skills through individual reflection and communication among students and the teacher.

Teaching presence is defined as "the design, facilitation and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile outcomes" (Anderson, Rourke, Garrison & Archer, 2001, p. 5). Teaching presence allows instructors to cross the transactional distance inherent in teaching online by structuring lessons and directing activities to meet student's needs. It also includes modeling critical thinking through communication and reflection and providing opportunities for student collaboration. Teaching presence "is the key element in integrating social and cognitive presence during the inquiry process" (Garrison & Aykol, 2012, p. 110). Research has shown that teaching presence is important for satisfaction and perceived learning (Arbaugh, 2008; Paechter, Maier, & Macher 2010; Swan & Shih, 2005), for knowledge construction (Kanuka & Anderson, 1998; Paechter et al., 2010), for promoting participation and encouraging quality responses (An, Shin, & Lim, 2009; Bliss

& Lawrence, 2009; Gorsky, Caspi, Antonovsky, Blau, & Mansur, 2010) and for the creation of the community of inquiry environment (Brook & Oliver, 2007; Ice, Curtis, Phillips, & Wells, 2007; Shea, Li & Pickett, 2006).

Social presence is defined as the ability of students in a community of inquiry to “project themselves socially and emotionally, as ‘real’ people (i.e., their full personality), through the medium of communication being used” (Garrison et al., 2000, p. 94). In the social presence theory of Short et al. (1976), social presence was viewed primarily as a quality of the communication medium being used (Lowenthal & Snelson, 2017). Theory and research have now moved beyond the early communication theorist’s assessment of a medium’s effect on social presence (Daft & Lengel, 1984; Short et al., 1976; Sproull & Kiesler, 1986) to the study of how connected students feel when using mediated communication (Swan & Shih, 2005) and how social presence can be developed through instructional practices to promote critical thinking (Garrison et al., 2000; Rogers & Lea, 2005). Social presence can be used to minimize feelings of isolation when learning online and can help students feel safe to share ideas and collaborate with others. Effective social presence allows for affective expression, open communication, and group cohesion (Garrison & Aykol, 2012). Tu and McIsaac (2002) demonstrated that social presence is an important factor in building a sense of community among online learners. Studies have also shown a relationship between social presence and perceived learning (Caspi & Blau, 2008; Lui, Gomez, & Yen, 2009; Richardson, Maeda, Lv & Caskurlu, 2017; Swan & Shih, 2005) and social presence and satisfaction (Arbaugh & Benbunan-Fich, 2006; Oyarzun et al., 2017; Richardson et al., 2017; Richardson & Swan, 2003). Findings are mixed on the relationship between social presence and retention; Boston et al. (2009) and

Liu, Gomez and Yen (2009) indicated a significant relationship while Joo, Kim, and Kim (2011) reported that social presence is not a predictor of persistence. The social presence of the instructor is also important and has been shown to have a positive effect on student achievement and satisfaction (Oyarzun et al., 2017).

Cognitive presence is defined as the extent to which students "are able to construct meaning through sustained communication" (Garrison, Anderson, & Archer, 2000, p. 89). Cognitive presence represents the student's learning pathway toward higher-order thinking skills. This pathway unfolds through a triggering event, exploration, integration, and finally, resolution (Garrison, Anderson, & Archer, 2001). Unfortunately, many early studies reported little activity in the integration and resolution phases (Garrison, et al. 2001; Kanuka & Anderson, 1998; Kanuka, Rourke, & Laflamme, 2007; Lee, 2014; Stein et al., 2007; Wanstreet & Stein, 2011). Garrison and Arbaugh (2007) argued that this may be due to a lack of teaching presence in the design and completion of the task towards these more advanced stages, while Shea & Bidjerano (2009b) suggested that studies need to consider other course artifacts for evidence of integration and resolution other than focusing only on discussion threads. More recent studies have resulted in greater activity in the integration and resolution phases (Akyol & Garrison, 2008; Akyol, Garrison, & Ozden, 2009; Richardson & Ice, 2010; Shea & Bidjerano, 2009b). Molnar and Kearney (2017) recently found that synchronous web conferences reached higher levels of cognitive presence, including the resolution phase, compared to asynchronous discussion sessions.

The original CoI framework (see Figure 1) shows how the three presences are interrelated. In order to foster collaborative inquiry, "social presence becomes a responsibility of teaching presence and a prerequisite for the occurrence of cognitive presence" (Garrison, Cleveland-Innes, & Fung, 2010, p. 32). Garrison and Cleveland-Innes (2005) argued that social presence alone does not guarantee critical discourse and meaningful learning, but it is difficult for discourse and cognitive engagement to develop without it. Similar to Moore's (1993) transactional distance constructs of dialogue and structure, Garrison and Cleveland-Innes (2005) found that interaction for cognitive success depends on structure and leadership (i.e., teaching presence). Shea and Bidjerano (2009a) and Garrison et al. (2010) showed that teaching presence significantly influenced both social presence and cognitive presence and that social presence significantly influenced cognitive presence. Seckman (2018) found a strong correlation between all three presences. This implies that social presence is needed in conjunction with teaching presence to increase cognitive presence (Garrison et al., 2010).

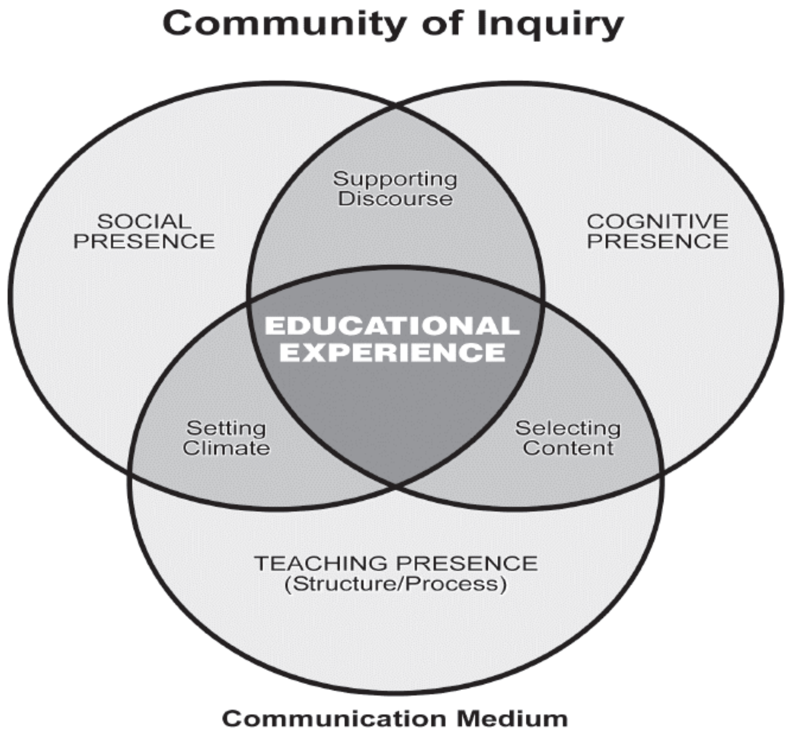

Figure 1. The Community of Inquiry Theoretical Framework. "Critical Inquiry in a Text-based Environment: Computer Conferencing in Higher Education," by D.R. Garrison, T. Anderson, and W. Archer, 2000, *The Internet and Higher Education*. *2*(2-3), p. 87-105. Copyright 2000 by Elsevier Science Inc. Reprinted with permission.

Recognition is growing among community of inquiry scholars that the CoI framework may need to be expanded. More recent studies suggest that metacognition or some other dimension that reflects student learning approaches is missing from the description of the original three presences (Aykol & Garrison, 2011; Garrison & Aykol, 2013; Shea et al., 2014). Shea et al. (2014) believed that self-regulated learning is a missing construct and called this *learning presence*. Learning presence encompasses the ability of online students to use forethought and planning, monitor understanding and completion, and use help strategies. Shea et al. (2012) demonstrated that students' perceptions of learning presence are positively correlated with final course grades. In addition, Krejins, Van Acker, Vermeulen and Van Buren (2014) argued that social presence actually represents two constructs, namely social presence, “the degree of ‘realness’ of the other in the communication”, and social space, “the degree to which social interpersonal relationships are salient” (p. 5). Armellini and De Stefani (2016) also suggested adjusting the CoI framework to make social presence more prominent arguing that teaching presence and cognitive presence have themselves “become social” and that social presence is not a self-contained concept. Clearly, the CoI framework is still a work in progress. The CoI framers admitted “the dynamic relationships among the presences could have been emphasized to a greater extent” (Garrison et al., 2010, p. 6).

Although some CoI research has suggested that the framework provides an important theoretical perspective and helpful model for studying online interaction and communication (Aykol et al., 2009; Garrison, 2007; Garrison et al., 2010; Garrison & Arbaugh, 2007), others have argued that CoI research does not offer evidence to support that social, teaching and cognitive presence constructs result in deep and meaningful learning (Annand, 2011; Rourke & Kanuka, 2009). Rourke and Kanuka (2009) concluded that CoI publications were focused more on student satisfaction, research measurement of the three presences, and students’ perceptions of learning, but failed to investigate the framework’s fundamental assertion that a student’s participation in an online learning environment rich with social, teaching and cognitive presence leads to deep and meaningful learning. The reliance of CoI research on self-reported perceived learning suggests a potential research limitation (Gonyea, 2005). Maddrell, Morrison and Watson (2017) furthered the argument that there is a lack of empirical evidence that social, teaching and cognitive presences in the learning environment are related to learning outcomes. Lowenthal and Snelson (2017) also argued that the CoI framework is an idealized model for certain types of online courses (i.e., collaborative online learning environments) and potentially for certain types of learners. Therefore, it may be of little value for students and courses that don't rely heavily on collaboration and social interaction. Obviously, more research is necessary. This research study focused on a learning environment rich with social, teaching and cognitive presence through implementation of synchronous group work sessions. The impact these sessions had on student academic success will thus further the research on how the CoI constructs effect learning.

Social presence. If one considers the technology used to support a CoI, older studies of social presence look at the dialogue and conversations created when utilizing text-based communication such as asynchronous discussion boards or synchronous chats. With the advance of more complex media tools like web conferencing, it is important to consider the effect these rich media tools have on social presence. Peacock et al. (2012) argued that synchronous media that incorporates both audio and video can be particularly helpful in promoting social, teaching and cognitive presence. A survey done by Salloum (2011) of special education teachers revealed that participants found tools such as email, discussion boards, news or announcements, web conferencing, and chats were helpful communication tools for social and teaching presence. Discussion forums were most helpful in fostering teaching presence, while using both discussion boards and web conferencing resulted in higher perceived cognitive presence than those using only web conferencing (Salloum, 2011). Wanstreet and Stein (2011) showed that cognitive presence is highly correlated with social presence in learner-led synchronous discussions. A study by Rockinson-Szapkiw et al. (2010) considered the use of both synchronous and asynchronous technologies in an online course. No difference in cognitive presence, teaching presence and perceived learning was found between students who used only asynchronous communication and students who used both asynchronous and synchronous communication. However, there was evidence that students who used a combination of both had greater social presence. Kim, Kwon, and Cho (2011) discovered that students' perceptions of media integration, the level of media availability and effective usage, predicted both social presence and learning satisfaction. Moreover, Liaw and Huang (2000) reported that delivery of online content through a variety of media positively impacted learner experiences, and Arbaugh (2005) corroborated that media variety was positively associated with perceived learning. Web conferencing was shown to provide a greater sense of teaching, social and cognitive presence than text-based communication (Seckman, 2018). In Seckman's (2018) study, web conferencing was used for group work and students listed it as one of the items most helpful in creating a sense of presence. These studies suggest that the addition of synchronous communication to an asynchronous online course may increase students' perception of social presence, and therefore may have the potential to improve online learning. Students also acknowledged that social interaction within synchronous discussions improved the collaborative learning process and increased their understanding and application of difficult material (Rockinson-Szapkiw et al., 2010). Based on the research, collaboration embedded into a course using synchronous learning tools may encourage active learning, foster problem solving, critical thinking and higher-order thinking skills as well as build a community of inquiry. Not only might working in groups promote a deeper understanding of the material, it could also provide cognitive support for learners and increase interpersonal interactions in the online classroom which may help strengthen a student's psychological connection to the course, enhance their social presence and lessen their transactional distance.

Connectivism

Connectivism is touted as a new learning theory for the digital age (Siemens, 2005). It applies network principles to the process of learning. In this model, knowledge emerges when learners make "connections between concepts, opinions and perspectives that are accessed via Internet technologies" (Dunaway, 2011, p. 676). Learning and knowledge are said to "rest in diversity of opinions" (Siemens, 2005). Connectivism stresses the importance of being able to seek out the most current information and filter out extraneous and secondary information (Kop & Hill, 2008). Learners continuously connect to a network to find and share new information, adjust their beliefs based on this new information, and reconnect to share new insights and seek further information (Goldie, 2016). The four key principles of learning in connectivism include autonomy, connectedness, diversity, and openness (Downes, 2005).

Connectivsim has been tested in massive open online courses (MOOCs; Tschofen & Mackness, 2012). MOOCs are online courses that attract a diverse and massive audience from around the world. They are open and free to all, and "participants are expected to openly share their expertise, knowledge, understanding, and ideas, so that knowledge is not only freely distributed across the network, but also created within the network" (Tschofen & Mackness, 2012, para. 5). MOOCs provide a structured curriculum around a particular topic, but require autonomous learners who can make their own social and conceptual connections (Tschofen & Mackness, 2012). The role of teacher changes to that of facilitator, or may disappear altogether (Kop & Hill, 2008). There has been concern over the lack of control, structure and moderation inside of MOOCs as well as the need for more guidance (Mackness et al., 2010). There are concerns about whether learners are motivated and capable of taking advantage of all the resources available in the network (Tschofen & Mackness, 2012). Not all people are autonomous learners. There may also be a lack of critical engagement online (Kop & Hill, 2008). Without the intervention and course design of teachers to make students aware of alternative points of view, there is a temptation for people to connect with like-minded folks (Mackness, Mak, & Williams, 2010). The four cornerstones of connectivism, autonomy, connectedness, diversity, and openness, can both enable and inhibit learning in a MOOC (Mackness et al., 2010). Pilli, Admiraal, and Salli (2018) addressed dropout rates, poor pedagogy and low-quality assessments as additional weaknesses of MOOCs. On the other hand, Kop and Fournier (2010) indicated that many learners appreciated the social aspects and sense of connectedness in networked learning as much as the conceptual connections being forged. Accessibility, lifelong learning, sense of community, and college brand extension represent additional strengths for MOOCs (Pilli et al., 2018). Ideally, connectivism provides opportunities for people to make choices about their learning. It promotes group collaboration and discussion, allowing for different viewpoints and perspectives to aid in problem-solving, decision-making, and making sense of information (Rank, 2018). However, Jaggars (2014b) remained skeptical of the "massive" nature of MOOCs. Research provides evidence that students prefer instructors who are engaged and show that they care about their students (Jaggars & Xu, 2013). This is even more so at community colleges, where instructor connection and encouragement of students is so important. “The content and activities that motivate students at elite universities for which MOOC materials were initially designed may not motivate students at other colleges” (Jaggars, 2014b, para. 14). While MOOCs appear to show that it is technically possible to connect large numbers of people, connectivity is not sufficient for connectedness and interactivity (Mackness et al., 2010). It remains to be seen if MOOCs will improve both access and success for students who are traditionally underserved (Jaggars, 2014b).

Connectivism supports the building of learning communities through the use of technology. The diversity of technology available, including asynchronous and synchronous means of communication, opens doors and access to new learning for many people. Many students in online classrooms are often provided instructional resources (video lectures, textbooks, course software) for learning content, but it is common for students to reach beyond the resources provided in the classroom and seek out additional help via the internet. This implies that learning in a traditional online classroom has the potential to evolve into a personal learning network for students beyond the domain of the classroom. However, research suggests that students will respond better and learn more if there continues to be significant student-teacher and student-student interaction along with teaching and social presence to guide students through the learning process (Garrison et al., 2010; Swan et al., 2000).

Online Interaction

The goal of online interaction is for students to work through shared course objectives by socializing and problem solving with fellow students and the instructor. Vygotsky (1978) asserted that social interaction is necessary to support learning. When students collaborate and encourage each other, they enhance the knowledge acquisition of the group. Interaction is necessary to support both community-building and learning (Rovai, 2002a). According to Palloff and Pratt (2007), "the learning community in an online course allows for mutual explorations of ideas, a safe place to reflect on and develop those ideas, and a collaborative, supportive approach to academic work" (p. 26). Ludwig-Hardman (2003) emphasized the online aspect by suggesting that a learning community is a "group of people, connected via technology-mediated communication, who actively engage one another in collaborative, learner-centered activities to intentionally foster the creation of knowledge, while sharing a number of values and practices" (p. iv). Rovai has been a leader in sense of community research, developing the Classroom Community Scale (CCS; Rovai, 2002b). He defined community in terms of four dimensions: spirit, trust, interaction, and learning (Rovai, 2002a, 2002b). Interaction factors into all of these definitions of community and has been shown to be an essential component for building community (Swan, 2001).

According to Anderson and Garrison (1998) and Moore (1989), there are three primary modes of interaction in online courses including student-to-content interaction, which refers to a student's ability to access and engage with content, leading to relevant knowledge construction; student-to-student interaction, which refers to students' ability to communicate with one another, collaborate on tasks, and engage in active learning together; and student-to-teacher interaction, which refers to a student's ability to communicate with and receive feedback, instruction, support, and motivation from the teacher. Anderson and Garrison (1998) proposed that in order to achieve "deep and meaningful learning," interaction between and among these three elements – content, student, teacher – must occur (see Figure 2).

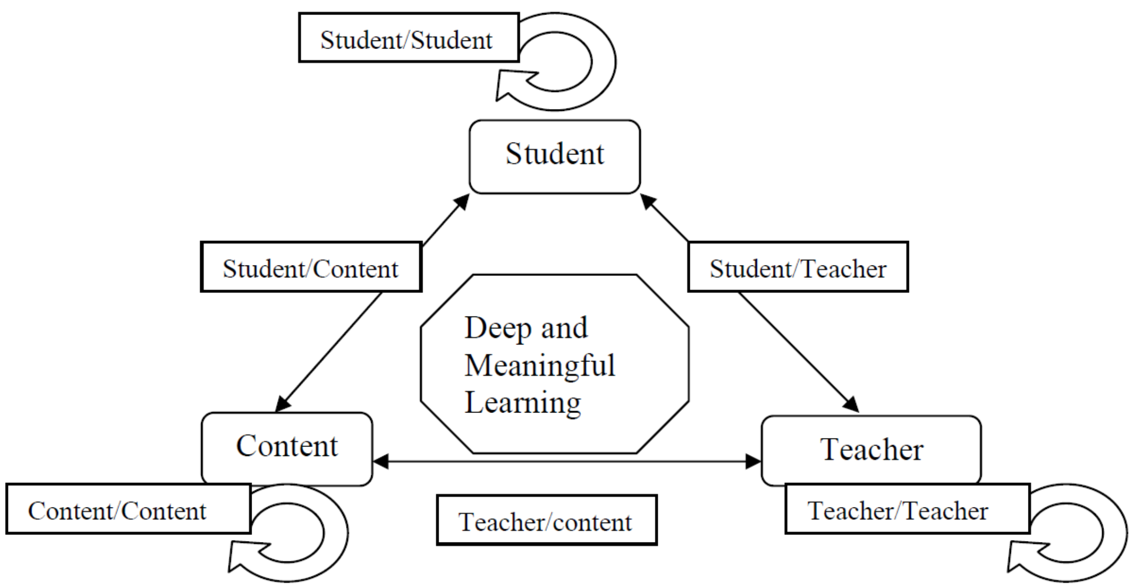

Figure 2. Modes of Interaction in Distance Education. "Learning in a Networked World: New Roles and Responsibilities" by T. Anderson and D.R. Garrison, 1998, in C. Gibson (Ed.), *Distance Learners in Higher Education*, p. 97-112, Madison, WI: Atwood Publishing. Copyright 1998 by Atwood Publishing. Reprinted with permission.

Hillman, Willis, and Gunawardena (1994) recognized a fourth type of interaction, student-interface, as the "process of manipulating tools to accomplish a task" (p. 34). It focused on the access, skills and attitudes needed for successful technology-mediated learning. Since all interactions in online learning are technologically-mediated, Friesen

& Kuskis (2012) contended that Hillman et al.'s student-interface interaction need not be viewed as a unique type of interaction, but as a factor of the other modes of interaction. Rovai (2001) suggested two different types of interactions that can help facilitate a sense of community. Task-driven interaction focuses on the completion of a task while socio-emotional interaction focuses on creating relationships between students. Anderson (2003) described the challenge of "getting the mix right" among the various modes of interaction. Individual students may need or prefer different types of activity and interaction. Anderson's equivalency theorem states that if the quality of the educational experience in any one mode of interaction is great enough, then deep and meaningful learning can occur. This theorem supports student differences and opposes the idea that there is one best approach to teaching or learning online. Though using all three modes of interaction may enhance the online environment, they may not all be necessary.

Interaction has been shown to have an impact on student satisfaction in online courses (Bray, Aoki, & Dlugosh, 2008; Kuo, Walker, Schroder, & Belland, 2014; Oyarzun et al., 2017; Rodriguez Robles, 2006; Sher, 2009) and student satisfaction is a major factor predicting attrition and retention (Park & Choi, 2009; Yang, Baldwin & Snelson, 2017). Given that student satisfaction may be positively related to cognitive learning outcomes, motivation, retention, persistence, and a more productive learning environment, it is worthwhile to investigate any aspects of online course design, like integrating interaction and building sense of community, that can impact sense of satisfaction. Oyarzyn et al. (2017) reported that interactions with a high level of collaborative or cooperative intent positively affected learner achievement, satisfaction and social presence. Some research has indicated that student-teacher interaction is the best predictor of student satisfaction (Arbaugh, 2001; Bolliger & Martindale, 2004), while others have shown that student-student interaction is better (Rodriguez Robles 2006). Swan et al. (2000) studied course satisfaction in a sample of 1406 students from 73 online university courses and found three factors that contributed significantly to student satisfaction. The three factors included contact with and feedback from the instructors (student-teacher interaction), active discussion among students (student-student interaction), and clarity in course design (student-content interaction). The study also concluded that high levels of participation and high levels of interaction with the teacher and fellow students led to the highest levels of perceived learning. Moreover, Yukselturk and Yildirum (2008) reported that the lack of social interaction in online courses led to low levels of satisfaction.

Synchronous interactions. Online interactions often occur via synchronous chat rooms and web conferencing or through asynchronous discussion boards, blogs or emails. Asynchronous communication appeals to students due to demands for flexibility. However, Hughes (2007) pointed out that “flexibility provides learners with more opportunities to disengage as well [as to] engage” (p. 709). Synchronous online tools have the potential to engage students in real-time social discourse. Research provides support for using synchronous technology to promote interactions and sense of community (Hrastinski, 2008). Web conferencing is a highly collaborative and social learning environment. It can support teacher presence and social presence and provides opportunities for students to interact and talk through issues or questions they encounter during the learning process. Kuo, Walker, Belland, Schroder, and Kuo (2014) indicated in their research that increased levels of interaction in web conferencing environments correlated with student satisfaction. Offir, Lev, and Bezalel (2008) showed that the amount of interaction in a synchronous class predicted the effectiveness of the course. While Haythornthwaite, Kazmer, Robins and Shoemaker (2000) and Rogers, Graham, Rasmussen, Campbell and Ure (2003) demonstrated that online students value multiple ways to interact, including both synchronous and asynchronous communication. McInnerney and Roberts (2004) suggested that the use of both asynchronous and synchronous forums for communication promoted productive social interaction and enabled a sense of community to exist. While, Wang and Newlin (2001) investigated the impact of synchronous communication on the social interaction of students and discovered a decrease in students' sense of isolation. Synchronous sessions have also been shown to have a strong sense of social presence, more so than asynchronous discussion (Oztok, Zingaro, Brett, Hewitt, 2013; Malikowski, Thompson, & Theis, 2007). Schullo, Hilbelink, Venable, & Barron (2007) reported that besides providing motivation and immediate feedback to students, synchronous technologies can also be used to enhance a student's sense of connectedness. Zhao et al. (2005) demonstrated that distance education programs with both synchronous and asynchronous interaction exhibited more positive outcomes than those with only one type of interaction.

Sense of Community

According to Rovai (2002b), "proper attention must be given to community building in distance education programs because it is a 'sense of community' that attracts and retains learners" (p. 199). Research has shown that dropout and failure rates in online courses are substantially higher than face-to-face courses (Hart et al., 2016; Jaggars & Xu, 2010; Xu & Jaggars, 2013). A feeling of loneliness and isolation is associated with disengagement and dropping out. Tinto (1993) stressed the importance of community in reducing dropouts by theorizing that students would experience greater satisfaction and likelihood of persisting in college if they had rewarding interactions with faculty and students in and out of the classroom and felt involved in a learning community. One strategy to help increase retention is to promote a strong sense of community through increased affective support. This has the potential to reduce feelings of isolation, allow students to connect with each other, and build a larger base for academic support (Rovai, 2002c). Rovai (2002c) also provided evidence that a greater sense of community within online courses can result in higher levels of perceived learning.

A sense of community is "the feeling that group members matter and that one's needs are satisfied through the collective effort of the group" (Yuan & Kim, 2014, p. 221). In online learning communities, students work with one another using technology to construct knowledge, complete tasks and achieve common goals with the understanding that community enhances the acquisition of learning. This can't happen without feelings of connectedness among classmates and the teacher. Feelings of friendship and cohesion among students develop into feelings of safety and trust, which leads to support in times of need. Oliphant and Branch-Mueller (2016) found that participation in group discussions and group work activities were necessary for developing and sustaining a sense of community. Rovai (2002a) suggested that instructors must enhance social presence in order to nurture and support a sense of community in the online classroom.

Research affirms the benefits of feeling a sense of community among online learners. Baturay (2011) and Liu et al. (2007) confirmed positive relationships between sense of community, course satisfaction, perceived learning and learner engagement. Rovai (2002c) and Liu et al. (2007) also found that a sense of community decreased feelings of isolation and increased satisfaction possibly lowering the risk of attrition. Moreover, sense of community has been proven to be positively related to motivation (Moller et al., 2005) and achievement (Wighting, Nisvet, & Spaulding, 2009). As Wighting et al. concluded, "learning has important social and cognitive dimensions and occurs most effectively when the school provides a positive social environment with a strong sense of community" (p. 64).

Evidence suggests that a sense of community can be created in the online classroom by promoting interaction (O'Hara, 2008; Palloff & Pratt, 2007; Stepich & Ertmer, 2003). Student-teacher and student-student interaction in online courses is positively correlated with students' sense of community (Baab, 2004; Lear, 2007). Baab also reported that online courses that blended both asynchronous and synchronous components were able to achieve a sense of community when high levels of interactivity and teaching presence were involved. Shea (2006) confirmed that a strong teaching presence was associated with a high sense of community. Rovai (2002a) recommended supplementing individual learning activities with small group work in order to promote a sense of community by helping students make connections together. Studies have also shown that online students believed collaborative group work was instrumental in developing a sense of community (Baturay & Bay, 2010; Oliphant & Branch-Mueller, 2016; Shackelford & Maxwell, 2012).

Yuan and Kim (2014) created guidelines for the development of an online learning community. One guideline suggested that both asynchronous and synchronous technologies should be used so that students and the instructor can interact. It was also advised that students be assigned tasks that require collaboration. Both of these guidelines align with the premise of this study. Though many studies recognize the significance of promoting social presence, interaction and collaboration to establish community (Cox & Cox, 2008; Sher, 2009; Swan, Garrison & Richardson, 2009; Yuan & Kim, 2014), many lack effective and specific approaches, course design, and technologies to achieve that goal. This study examined the effectiveness of using synchronous, collaborative sessions using a web conferencing tool as a means to increase success and community in the online classroom. The research presented suggests that these techniques should be effective and beneficial for students.

Online Group Work

Group work is an example of collaborative learning. In group work, students construct knowledge by discussing and interacting with their peers and instructor. A multitude of research supports the benefits of group work, confirming that collaborative learning supports active learning, increases motivation, fosters mutual concern, promotes critical thinking, and encourages socialization (Gillies & Ashman, 2003; Hassanien, 2007; Johnson & Johnson 2003; Sharan, 1980; Slavin, 1980). Successfully implementing online group work, either synchronously or asynchronously, has proven to be a challenge (Gillet-Swan, 2017), with little research demonstrating its effectiveness. Mayer et al. (2017) implemented synchronous online group work sessions via web conferencing among advanced high school math students. The study demonstrated how web conferencing can increase student involvement and satisfaction, as well as social cohesion, but no difference in final grades due to the synchronous group work sessions was documented. Huang et al. (2016) found that students who were required to work in small group discussions or class discussions reported lower transactional distance than those not required to do so. Online group work has also been shown to reduce feelings of isolation and promote the development of higher order thinking skills, like reflection (Hassanien, 2007; Palloff & Pratt, 2013). Berbunan-Fich and Arbaugh (2006) established that success in online courses depends on collaborative learning activities and/or challenging environments where students create their own knowledge. When students interact through collaborative activities, participation and connectedness increase due to helpful peer feedback, sharing of experiences and the development of critical thinking skills (Boerema, Stanley, & Westhorp, 2007; Holley & Dobson, 2008; Hassanien, 2007). In addition, collaboration can deepen understanding of the content, foster higher order thinking, and provide satisfaction and comfort (Engstrom, Santo, & Yost, 2008). Therefore, group work has the potential to support learning and increase student academic success. Springer et al. (1999) confirmed that cooperative learning in STEM fields positively impacted achievement and persistence. Collaboration also has the likely effect of enhancing sense of community. Rovai (2002c) was able to demonstrate a greater sense of online community and greater perceived cognitive learning using collaborative activities.

In order to implement group work in the online classroom, synchronous interactions were effective (Falloon, 2011; Strang, 2013). In fact, deeper learning and community resulted when group projects utilizing rich synchronous media tools were used (Overbaugh & Casiello, 2008; Rockinson-Szapkiw & Wendt, 2015; Strang, 2013). The traditional face-to-face classroom allows students to get immediate feedback on questions to clarify concepts. In the online classroom, answers to questions are often delayed leading to frustration and a lack of motivation. However, online group work facilitated by a rich media tool could provide real-time interaction that would promote conversation, collaboration, and community, while simultaneously engaging students in learning.

Chapter III - Method

This study explored whether synchronous online group work sessions could increase students' academic success in online mathematics courses and promote a sense of community in the online classroom at the community college level. The study employed a quasi-experimental design complemented by a brief series of open-ended questions to test five hypotheses. A sample of convenience was utilized, and the participants were not randomly assigned to conditions. Thus, causal inference and generalizability were limited relative to a true experimental design (Cozby & Bates, 2018). First, it was hypothesized that student formative academic success in online college-level math courses would be greater when synchronous group work sessions were implemented. Second, it was hypothesized that student summative academic success in online college-level math courses would be greater when synchronous group work sessions were implemented. Third, it was hypothesized that sense of community in online college-level math courses would be greater with utilization of synchronous group work sessions. Fourth, it was hypothesized that there would be a positive correlation between sense of community and student formative performance. Fifth, it was hypothesized that there would be a positive correlation between sense of community and student summative performance.

Participants

The sample for this study were undergraduate students in online college-level mathematics courses at community colleges during Fall semester 2019. Two online mathematics instructors agreed to be involved in the study, and the students from their online Statistics and College Algebra classes participated in the study as a sample of convenience. The students came from two Midwestern suburban community colleges. The community colleges offer both transfer-oriented and occupationally-oriented degrees. Students either placed directly into Introductory Statistics based on assessment scores, or successfully completed a developmental level Introductory Algebra course within two years prior to enrollment in Statistics. Students either placed directly into College Algebra based on assessment scores, or successfully completed a developmental level Intermediate Algebra course within two years prior to enrollment in College Algebra. Students were not required to take any orientation to online classes prior to enrollment. Course data were collected from four classes, of which two classes were taught at each of the two community colleges. All participants included in the study completed an online consent form. Neither students nor instructors were compensated for their participation.

Each instructor had pedagogical control within their own online classrooms. To control for such natural differences in pedagogy, each of the instructors taught two sections of the same course. The control sections were taught primarily through an asynchronous mode, as the instructor would normally teach the course online. The treatment sections incorporated required synchronous online group work sessions every week in addition to the normal asynchronous course activities and assignments.

A total of 134 students initially enrolled in the Statistics and College Algebra course sections involved in the study. Sixty-nine of these students (51%) participated in the study. Students were disqualified from the study if they did not provide initial consent, were not at least 18 years old, did not complete both surveys, or withdrew from the course. Participants were 59% female (n = 41), 39% male (n = 27), and 1% other (n

= 1). Ages ranged from 18 years old to 50 years old with a mean age of 25.47. The majority of participants (70%, n = 48) reported that they were employed more than 20 hours per week while also in school. Even though 77% of participants (n = 53) reported taking an online course in the past and 78% (n = 54) had previously taken a college-level math course, only 36% (n = 25) had prior experience taking a college-level math course online (see Table 1).

Specifically, in the Statistics courses, the demographic characteristics were very similar to all combined sections (see Table 2). There were 20 participants in the treatment section and 19 participants in the control section. The typical Statistics participant was female (59%, n = 23) with an average age of 25 who worked more than 20 hours per week (64%, n = 25). In addition, she had prior online experience (72%, n = 28) and had taken a prior college-level math course (72%, n = 28), but not an online math course before (69%, n = 27).

Similarly, in the College Algebra courses, 15 students each participated in the treatment and control sections (see Table 3). The typical College Algebra participant was female (60%, n = 18) with an average age of 26 who worked more than 20 hours per week (77%, n = 23). She also had comparable prior math and online experience, though at slightly higher rates than in Statistics and all courses combined. The typical College Algebra participant had prior online experience (83%, n = 25), had taken a prior college-level math course (87%, n = 26) but not a prior online math course (57%, n = 17).

Table 1

Demographic Characteristics for Both Statistics and College Algebra Courses Combined

	Treatment			Combined Control			Total		
	N=35	%	M	N=34	%	M	N=69	%	M
Prior Online									
Yes	26	74%		27	79%		53	77%	
No	9	26%		7	21%		16	23%	
Prior Online Math									
Yes	14	40%		11	32%		25	36%	
No	21	60%		23	68%		44	64%	
Prior Math									
Yes	28	80%		26	76%		54	78%	
No	7	20%		8	24%		15	22%	
Age			25.41			25.53			25.47
18-19	8	24%		9	26%		17	25%	
20-29	15	44%		17	50%		32	47%	
30-39	10	29%		6	18%		16	24%	
40-49	1	3%		0	0%		1	1%	
50-59	0	0%		2	6%		2	3%	
Gender									
Female	15	43%		26	76%		41	59%	
Male	19	54%		8	24%		27	39%	
Other	1	3%		0	0%		1	1%	
Employment									
Work ≤ 20	11	31%		10	29%		21	30%	
Work > 20	24	69%		24	71%		48	70%	

Note. One student in Treatment Statistics did not disclose age, so N = 34 for Age category in Treatment and N = 68 for Age category in Total.

Table 2

Demographic Characteristics for Statistics Courses

	Treatment			Statistics Control			Total		
	N=20	%	M	N=19	%	M	N=39	%	M
Prior Online									
Yes	14	70%		14	74%		28	72%	
No	6	30%		5	26%		11	28%	
Prior Online Math									
Yes	8	40%		4	21%		12	31%	
No	12	60%		15	79%		27	69%	
Prior Math									
Yes	16	80%		12	63%		28	72%	
No	4	20%		7	37%		11	28%	
Age			26.5			24.2			25.3
18-19	4	21%		6	32%		10	26%	
20-29	7	37%		11	58%		18	47%	
30-39	7	37%		1	5%		8	21%	
40-49	1	5%		0	0%		1	3%	
50-59	0	0%		1	5%		1	3%	
Gender									
Female	9	45%		14	74%		23	59%	
Male	10	50%		5	26%		15	38%	
Other	1	5%		0	0%		1	3%	
Employment									
Work ≤ 20	7	35%		7	37%		14	36%	
Work > 20	13	65%		12	63%		25	64%	

Note. One student in Treatment Statistics did not disclose age, so N = 19 for Age category of Treatment and N = 38 for Age category in Total.

Table 3

Demographic Characteristics for College Algebra Courses

	College Algebra								
	Treatment			Control			Total		
	N=15	%	M	N=15	%	M	N=30	%	M
Prior Online									
Yes	12	80%		13	87%		25	83%	
No	3	20%		2	13%		5	17%	
Prior Online Math									
Yes	6	40%		7	47%		13	43%	
No	9	60%		8	53%		17	57%	
Prior Math									
Yes	12	80%		14	93%		26	87%	
No	3	20%		1	7%		4	13%	
Age*			24			27.3			25.6
18-19	4	27%		3	20%		7	23%	
20-29	8	53%		6	40%		14	47%	
30-39	3	20%		5	33%		8	27%	
40-49	0	0%		0	0%		0	0%	
50-59	0	0%		1	7%		1	3%	
Gender									
Female	6	40%		12	80%		18	60%	
Male	9	60%		3	20%		12	40%	
Other	0	0%		0	0%		0	0%	
Employment									
Work ≤ 20	4	27%		3	20%		7	23%	
Work > 20	11	73%		12	80%		23	77%	

To determine whether any statistically significant differences in demographics existed between treatment and control participants, an independent t-test was computed along with Cohen's *d* to establish any effect size. Grouping all treatment participants together and all control participants together, both gender (p = .024, d = -.556) and Pre Learning CCS (p = .083, d = .424) had moderate effect sizes. The treatment sections contained more male students, while the control sections had higher Pre Learning CCS scores. This was replicated in both Statistics and College Algebra (see Table 4).

The Statistics course had a small negative effect relative to the demographics of prior online math experience (p = .210, d = -.409), prior math (p = .254, d = -.371) and age (p = .335, d = -.317). Thus, the treatment section of Statistics had slightly more participants with online math experience and prior college-level math background, while also being slightly older students. In contrast, College Algebra had a small positive effect on prior math (p = .299, d = .386), implying that the control section had more students with prior math experience, and were slightly older (p = .261, d = .419). Control students in College Algebra also had a significantly larger Pre Learning CCS score (p = .028, d = .844), while treatment students had a moderately larger Pre Connect CCS score (p = .291, d = -.393).

Table 4

Demographic Differences between Treatment and Control by Course

		Treatment		Control			
		M	SD	M	SD	*p*	*d*
Pre Learning CCS							
	Combined	28.42	5	30.38	4	.083	.424
	College Algebra	27.20	4	30.33	3	.028	.844
	Statistics	29.35	5	30.42	5	.524	.206
Pre Connect CCS							
	Combined	23.94	5	23.11	5	.486	-.169
	College Algebra	25.33	5	23.40	5	.291	-.393
	Statistics	22.90	5	22.90	5	.997	-.001
Gender							
	Combined	1.51	.6	1.23	.4	.024	-.556
	College Algebra	1.60	.5	1.20	.4	.025	-.864
	Statistics	1.45	.6	1.26	.5	.284	-.349
Age							
	Combined	25.41	7	25.52	8	.950	.015
	College Algebra	24.00	6	27.27	9	.261	.419
	Statistics	26.53	7	24.16	8	.335	-.317
Prior Online Math							
	Combined	.40	.5	.32	.5	.516	-.157
	College Algebra	.40	.5	.47	.5	.724	.130
	Statistics	.40	.5	.21	.4	.210	-.409
Prior Math							
	Combined	.80	.4	.77	.4	.727	-.084
	College Algebra	.80	.4	.93	.3	.299	.386
	Statistics	.80	.4	.63	.5	.254	-.371

Measures

The online Introduction to Statistics and College Algebra courses typically used a variety of instructional methods from the following: video lectures created by the instructor, textbook author, or publisher, discussion board use for homework questions, graded homework activities and labs submitted through an online dropbox or completed via course software, online chapter quizzes using course software, and comprehensive exams. Nonetheless, all four courses used some combination of pedagogy that resulted in student learning assessed through homework assignments and examinations. Following the end of the semester and submission of course grades, consenting subject data (i.e., homework scores, discussion board post scores, group work participation grades, quiz and course exam grades, and final course grade) from Fall 2019 was collated by the course instructors and given to the researcher.

The independent variable was utilization of synchronous online group work sessions throughout the semester. The treatment group utilized the synchronous group work sessions, while the control group did not. The dependent variables were student academic success and sense of community. Academic success was measured by cumulative final course grades as a percentage. Course completion (academic success) was defined as successfully completing a course with an A, B or C grade, or 70% or above as a percentage. Earning any other grade (D, F, NC, I, W, or FN, or below 70%) was not considered course completion or academic success since the student would need to retake the class in order to move on to the next course. The final course grade percentage represented the student's summative learning score. In addition to this summative score, all homework assignment scores (including Statistic lab assignments) were averaged together to represent the student's formative learning score. These formative and summative scores were analyzed to determine the impact of the treatment as well as to investigate any correlation with sense of community or demographic characteristics.

Sense of community was measured using Rovai's Classroom Community Scale (CCS; Rovai, 2002b). The CCS was developed for use with university students taking online courses. It measures sense of community in a learning environment. The scale was rated for content validity by a panel of experts and the scale's construct validity was supported. Cronbach's alpha for internal validity was found to be 0.93. This instrument included 20 statements using a Likert-type 5-point scale to determine an overall classroom community score along with subscores for connectedness and learning (Rovai, 2002b). Examples of survey questions include, ''I feel that students in this course care about each other,'' ''I feel that I receive timely feedback,'' and ''I feel that my educational needs are not being met.'' The CCS was administered twice during the semester, first as a pre-test two weeks into the semester, and then as a post-test during the last two weeks of the semester (see Appendices A and B).

A short questionnaire was also administered to the treatment group. This questionnaire asked for student perceptions of how helpful the synchronous group work sessions were in learning the course content and building a sense of community. Additional demographic data (previous math and online experience, gender, work status, age, and location) was collected from both the treatment and control groups (see Appendices C and D).

Procedure

The treatment group required student attendance in weekly video-conferencing sessions using Adobe Connect, moderated by the course instructor. The sessions were used primarily for group work activities. The sessions were offered every week (with two time options provided to students to allow for flexibility in scheduling) over the course of the semester. Participation points at these required sessions was built into the grading scheme to encourage student attendance. The control group was taught asynchronously as the course instructor normally would, with no synchronous group work sessions added.

In the online classroom used in this study, Adobe Connect was used to facilitate the whole class and small group discussions and activities. Using headsets with microphones, students and the instructor interacted online in real-time. A webcam was available to display the instructor and potentially students (if they chose). Many synchronous tools were used to conduct the online group sessions including text chat, Voice-Over Internet Protocol (VOIP) audio, real-time presentation, breakout rooms for small group activities, white board presentations, class polling instruments, and application sharing. Synchronous group work sessions typically started off with an ice-breaker welcome and opening exercise or poll, followed by 2-3 group work problems to be solved in small randomly assigned groups using breakout rooms in Adobe Connect. The session ended with a discussion of any homework questions that students might raise. Students were expected to solve problems in groups using the shared whiteboard and display their work for the rest of the group and class to see.

Both instructors have taught online for at least 4 years, including experience teaching Statistics or College Algebra online. One instructor received Quality Matters (QM) training and one of her other online courses has gone through the QM review process and received QM certification. The other instructor has participated in a full-day QM training and consulted with fellow online instructors. While it is understood that instructor experience and course design can be very impactful on student learning, this study was not able to control for these factors due to the sample of convenience.

One instructor had some initial experience with Adobe Connect, using it for online office hours. Both instructors were trained before the semester began on how to use Adobe Connect to moderate the group work sessions. It was anticipated that students would have had no previous experience with Adobe Connect, therefore students in the treatment group received communication ahead of the semester outlining the expectations and technological requirements of the course. The syllabus outlined a synchronous group work session participation rubric (see Appendix F). An online video tutorial of how to use Adobe Connect along with instructional handouts and technological support was made available to students at the beginning of the semester. Students were required to use a microphone headset to minimize sound feedback and were encouraged to hardwire their computer to their router to maximize connection speed. The first session was spent introducing and training students in how to use Adobe Connect and how to handle technological issues. The instructors had access to institutional technical support for Adobe Connect if questions arose during the semester. The potential for recording sessions in Adobe Connect exists, however, only the audio and video in the main room can be recorded, not what happens inside the smaller breakout rooms. Since the majority of the synchronous sessions were spent in breakout rooms, the instructors chose not to record any of the group work sessions.

The Classroom Community Scale (Rovai, 2002b) was administered by the researcher using a Qualtrics survey to all participants during the second week of class. This acted as the baseline pre-test sense of community score. The CCS was then given again as a post-test during the last two weeks of the semester so that change could be measured for each student. At the end of the semester, the treatment group was also given a brief questionnaire (see Appendix C) offering three open-ended questions asking for student perceptions of how helpful the synchronous group work sessions were in learning the course content and building a sense of community, one question about their comfort level with Adobe Connect, and seven self-reported student demographic information questions (previous math and online experience, gender, work status, age and location). Participants in the control group received a similar demographic questionnaire without the items regarding perceptions of the synchronous group work sessions (see Appendix D). The CCS and the brief questionnaire took students approximately fifteen minutes to complete. The CCS and survey were administered using Qualtrics. In addition, the researcher debriefed with the course instructors regularly throughout the semester and administered a brief instructor survey at the end of the semester asking for instructor experiences with the synchronous sessions (see Appendix E).

Data Analysis

After grades were submitted, the course instructors submitted their gradebooks to the researcher for those students who provided consent. From this collection, the mean percentage earned on homework (based on weekly homework and lab assignment grades) was calculated and comprised the student's formative score. The student's summative score was based on the final grade percentage earned by the student at the end of the semester. Descriptive statistics were also compiled for participant demographic data. Participants' pre-test and post-test scores on the CCS were tabulated, including the overall classroom community score and connectedness and learning subscale scores. Response means for each questionnaire item were considered.

The data were analyzed using t-tests and Cohen's *d* to determine the effects and interactions of the treatment and course on academic success and sense of community. In addition, any statistically significant differences based on demographics were also considered. The Pearson product-moment correlation coefficient was used to identify whether relationships existed between formative success, summative success, and sense of community. Response frequencies were identified in the qualitative treatment group questionnaire and instructor survey responses to add student and instructor perspective to the treatment group's experiences. Key words or phrases mentioned in the qualitative responses were recorded and common codes were tallied using response frequencies.

Chapter IV - Results

This study explored the effects of embedded synchronous group work sessions on student academic success and sense of community. A pilot version of this study was conducted in the researcher's online Introductory Algebra course during the spring semester of 2019. Introductory Algebra is a developmental course, not college-level. Therefore, students in this course place below college-level mathematics and are required to take this non-credit bearing remedial course before moving forward. The class was taught online with embedded synchronous group work sessions. For a control, course data were compared to the online Introductory Algebra course taught by the same instructor in spring 2018 without synchronous group work sessions. Although the sample size was quite limited, results suggested a trend of higher scores on the midterm exam, final exam, and formative and summative scores for those students in the treatment section with synchronous components. In addition, there appeared to be a development trajectory of growth over the duration of the semester among the treatment group. With these significant limitations in mind, the pilot demonstrated promise that synchronous group work sessions could have the potential to increase students' academic success.

This dissertation study took place in Fall 2019 in two Statistics and two College Algebra online courses at two different community colleges. Before addressing the hypotheses set forth in the study, it is important to consider how well students were served by the course in terms of successfully passing the class. In this interest, Table 5 represents the pass rates of those participants who completed the course. While sample sizes are quite small, and results may be due to student idiosyncrasies, the results show that a majority of students passed both Statistics and College Algebra regardless of treatment. While it is unusual for 100% of students to pass Statistics as occurred in the control section (n = 19), it is common for 60% of students (or less) to pass College Algebra as resulted in the control section (n = 15). It appears that the treatment intervention did not harm students in passing Statistics, as a respectable 80% passed (n = 16). As well, the College Algebra treatment students fared better than the control section with their pass rate of 80% (n = 12).

Table 5

Pass Rates of Participants

	Statistics				College Algebra			
	Treatment N=20		Control N=19		Treatment N=15		Control N=15	
	% pass	% not pass	% pass	% not pass	% pass	% not pass	% pass	% not pass
Participants	16/20 80%	4/20 20%	19/19 100%	0/19 0%	12/15 80%	3/15 20%	9/15 60%	6/15 40%

Note. Pass is defined as a final grade percent of 70% or above; Not pass is defined as a final grade percent below 70%.

Academic Success

To address the impact of the synchronous group work sessions on student academic success, formative and summative scores were compared based on treatment. In the Statistics course, formative scores consisted of the mean grade on all homework and lab activities. The twelve homework and eleven lab activities included problem sets that students had to complete on paper (for the homework) and using statistical software (for the labs). In the College Algebra courses, there were six homework sets assigned using an online mathematical homework software, and the formative score consisted of the mean homework grade. The summative score was represented by the student's final course percentage in the class. In addition, the midterm and final exam scores were also taken into consideration. An independent samples t-test confirmed no statistically significant difference in formative, summative, midterm exam or final exam scores based on treatment (see Table 6). Only the midterm exam scores (p = .549, d = -.145) were slightly higher in the treatment sections, though not significantly, while the formative (p = .021, d = .570), summative (p = .443, d = .185) and final exam scores (p = .228, d = .295) were all higher in the control section. Surprisingly, there was a medium effect (d = .570) on the formative score such that the treatment had a negative effect on homework/lab grades. The mean formative score for the control sections (92%) was more than a grade higher than the mean formative score for the treatment sections (82%), however the standard deviation was quite large in the treatment section (SD = 24) compared to the control (SD = 9) suggesting wide variability in homework/lab scores for the treatment students. This may indicate preexisting student differences relative to homework scores, ability, and habits, since this discrepancy in variability is not as pronounced in the summative, midterm or final exam scores.

Similar results exist when considering Statistics and College Algebra courses independently (see Table 7). Both show a medium to large effect size in formative scores (d = .450 for Statistics, d = .721 for College Algebra), with a big disparity in the standard deviations (Statistics: SD = 24 for treatment, SD = 10 for control; College Algebra: SD = 24 for treatment, SD = 6 for control). Likewise, only the midterm exam scores were slightly higher, though not significantly, in the treatment sections (Statistics: 88; College Algebra:73) compared to the control (Statistics: 87; College Algebra:68). All other formative, summative and final exam mean scores were lower in the individual treatment sections. Graphical representations display the spread of formative, summative, midterm and final exam scores in both courses combined (see Figures 3 through 6). As these distribution plots confirm, the treatment sections contain lower minimum scores which widens the range of values achieved. These outliers increase the variability and drag the mean formative, summative, and final exam scores lower than the control section.

Table 6

Formative, Summative, Midterm Exam, and Final Exam Scores for all Participants

	Combined					
	Treatment		Control			
	M	SD	M	SD	*p*	*d*
Formative	82	24	92	9	.021	.570
Summative	78	17	81	13	.443	.186
Midterm	81	18	79	17	.549	-.145
Final Exam	67	23	73	17	.228	.295

Table 7

Formative, Summative, Midterm Exam, and Final Exam Scores by Course and Treatment

	Statistics						College Algebra					
	Treatment		Control				Treatment		Control			
	M	SD	M	SD	*p*	*d*	M	SD	M	SD	*p*	*d*
Formative	81	24	90	10	.168	.450	82	24	95	6	.058	.721
Summative	82	14	86	9	.362	.295	73	20	75	14	.733	.126
Midterm	88	7	87	14	.767	-.096	73	24	68	18	.594	-.197
Final Exam	68	20	74	17	.358	.368	67	27	72	24	.574	.212

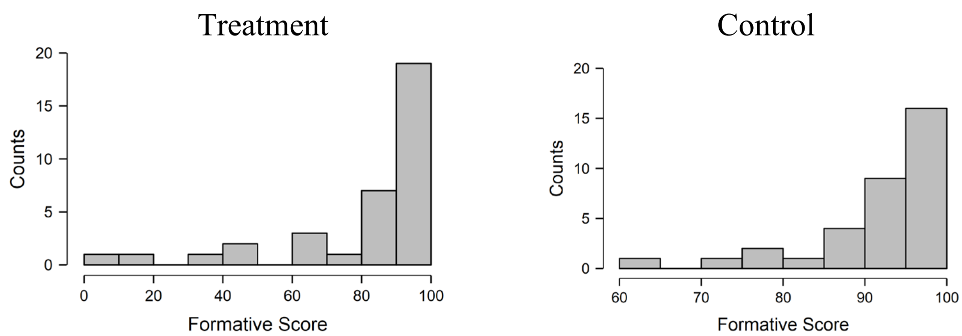

Figure 3. Formative Scores Distribution Plot for Combined Courses

Note differences in horizontal scale.

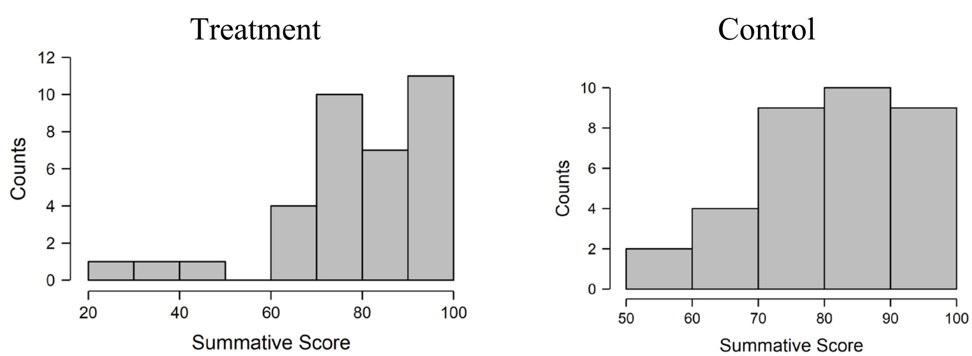

Figure 4. Summative Scores Distribution Plot for Combined Courses

Note differences in horizontal scale.

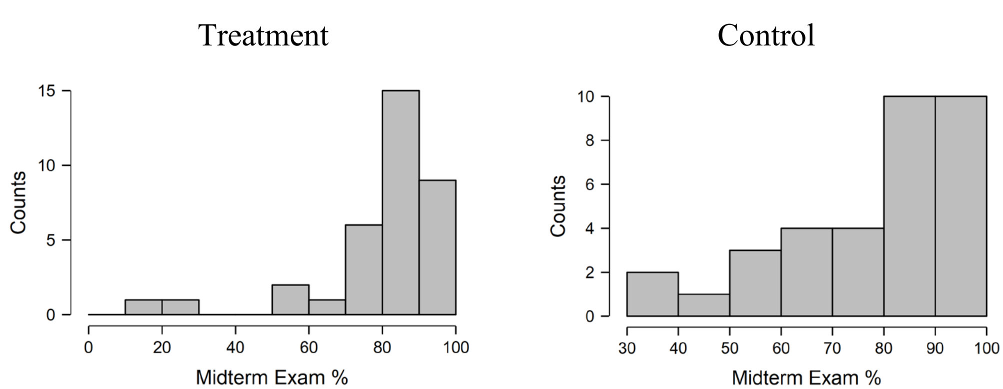

Figure 5. Midterm Exam Scores Distribution Plot for Combined Courses

Note differences in horizontal scale.

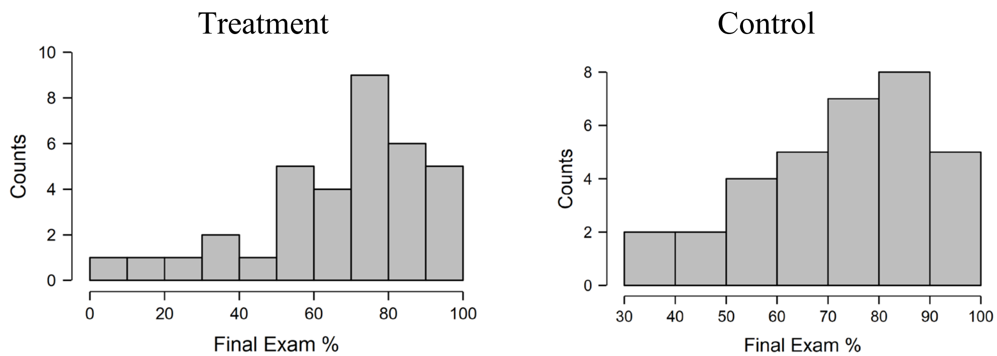

Figure 6. Final Exam Scores Distribution Plot for Combined Courses

Note differences in horizontal scale.

Requiring students to attend synchronous group work sessions once a week puts a burden on online students to meet at a prescribed time and reduces the flexibility inherent in online classes. One concern in this study was that if students were unable to attend weekly sessions due to conflicts, this would negatively affect the student's summative score. In order to see if attendance in the Adobe Connect sessions significantly impacted overall grades, a comparison was made between the original summative scores and revised summative scores with the attendance grades for the Adobe Connect sessions removed. Overall grades were higher with the Adobe Connect attendance factored in, though not significantly ($p = .247$, $d = -.226$), therefore, it appears that the attendance requirement did not negatively affect students passing the course (see Table 8).

Table 8

Comparison of Summative Scores with Adobe Connect Attendance vs Summative Scores without Adobe Connect Attendance for all Participants

Summative Score with Adobe Connect		Summative Score without Adobe Connect			
M	SD	M	SD	*p*	*d*
78	17	74	19	.347	-.226

Hypothesis 1 predicted that student formative academic success in online college-level math courses would be greater when synchronous group work sessions were utilized. Moreover, hypothesis 2 asserted that student summative academic success in online college-level math courses would be greater when synchronous group work sessions were utilized. Unfortunately, this study was not able to demonstrate greater formative or summative scores in two online college-level math courses as a result of implementation of synchronous group work sessions.

Sense of Community

Another focal point of this study was on the effect of synchronous group work sessions on sense of community. Sense of community was measured using Rovai's Classroom Community Scale (CCS; Rovai, 2002b). This instrument included 20 statements using a Likert-type 5-point scale to determine an overall classroom community score along with subscores for connectedness and learning (Rovai, 2002b). Overall CCS scores could range from 0 to 80, with each of the subscales measuring at most 40. Participants completed the CCS as a pretest during the second week of the semester, and again as a posttest during the last two weeks of the semester. To measure change in sense of community, this study calculated Post–Pre CCS, where a positive change indicated growth in sense of community.

When considering all courses combined, there were no statistically significant differences in CCS or the connectedness or learning subscales. The change in CCS for all combined courses had a small negative effect (p = .325, d = -.239) suggesting that treatment had a small effect on increasing sense of community, with the mean CCS scores rising from 52 to 54. This was evident as well in the learning subscore (p = .302, *d* = -.251) increasing from 28 to 30 in the treatment section, and staying at 30 in the control section (see Table 9).

In the Statistics course, these changes were even less significant, with no measurable effect size in Post-Pre CCS (p = .793, d = .084), Post-Pre Connectedness (p = .779, d = -.091), or Post-Pre Learning (p = .569, d = .185). However, there was a much greater impact on sense of community due to treatment within the College Algebra sections. The Post-Pre CCS had a medium effect (p = .112, d = -.599), a small effect on connectedness (p = .518, d = -.239), and a large effect with a statistically significant difference on the learning subscale (p = .033, d = -.819). Although the sample size is very small, the treatment intervention appears to have increased sense of community, especially in the learning subscale, in the College Algebra course (see Table 10).

Table 9

Sense of Community by Treatment for all Courses Combined

	Treatment		Combined Control			
	M	SD	M	SD	*p*	*d*
Pre CCS	52	9	54	8		
Post CCS	54	12	53	8		
Post-Pre CCS	1.9	10	-1.9	9	.325	-.239
Pre Connect	24	5	23	5		
Post Connect	25	6	23	4		
Post-Pre Connect	.6	4	-.1	4	.491	-.167
Pre Learning	28	5	30	4		
Post Learning	30	5	30	5		
Post-Pre Learning	1.3	6	-.1	6	.302	-.251

Table 10

Sense of Community by Course and Treatment

	Statistics						College Algebra					
	Treatment		Control				Treatment		Control			
	M	SD	M	SD	*p*	*d*	M	SD	M	SD	*p*	*d*
Pre CCS	52	9	53	8			53	9	54	7		
Post CCS	53	12	55	9			56	11	52	6		
Post-Pre CCS	.5	7	1.2	10	.793	.084	3.9	12	-2	6	.112	-.599
Pre Connect	23	5	23	5			25	5	23	5		
Post Connect	23	6	23	5			26	6	23	3		
Post-Pre Connect	.6	3	.2	4	.779	-.091	.7	6	-.5	4	.518	-.239
Pre Learning	29	5	30	5			27	4	30	3		
Post Learning	29	7	31	5			30	7	29	4		
Post-Pre Learning	-.1	4	1	7	.568	.185	3.2	8	-1.5	3	.033	-.819

Hypothesis 3 proposed that student sense of community in online college-level math courses would be greater when synchronous group work sessions were utilized. Though this was not the case when considering all courses combined, there was a statistically significant increase in sense of community relative to learning in the College Algebra treatment section, small sample size notwithstanding. There was also a moderate effect on the overall CCS in the College Algebra course, implying the intervention promoted growth in sense of community. Sense of community for all courses combined was diminished by the fact that there was no overall impact of treatment on sense of community in the Statistics course. Thus, in general, hypothesis 3 cannot be validated, and it appears that sense of community was not greater as a result of synchronous group work sessions in online college-level math courses.

Correlations

The next aim for this study was to examine whether any correlations existed between sense of community and formative and summative scores, as well as any relationships with or between demographic characteristics. A correlation matrix was generated to determine any relationships. There were obvious, and to be expected, strong positive correlations between formative scores and summative scores (r = .694), midterm exam and summative scores (r = .831), and final exam and summative scores (r = .834). As well, there were small to medium sized correlations between midterm and final exam scores (r = .675), midterm and formative scores (r = .352) and final exam and formative scores (r = .487). The better students did on homework, the better they performed on exams and in the overall course. Refer to Table 11 for the correlation matrix relative to academic measures for all combined courses.

Table 11

Correlation Matrix of Academic Measures for all Combined Courses

	Formative		Summative		Midterm Exam	
	r	*p*	*r*	*p*	*r*	*p*
Summative	.744	<.001				
Midterm Exam	.564	.001	.912	<.001		
Final Exam	.622	<.001	.926	<.001	.890	<.001

Among all combined courses, there were also small positive correlations between Post-Pre CCS and formative scores (r = .242), summative scores (r = .304), midterm exam scores (r = .247) and final exam (r = .240) scores. These correlation coefficients were all slightly higher in the College Algebra course and slightly smaller in the Statistics course, with the exception of the correlation between Post-Pre CCS and the formative scores (see Table 12).

Table 12

Correlation Matrix between Post-Pre CCS and Academic Measures by Course

	Formative		Summative		Midterm Exam		Final Exam	
Post-Pre CCS	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Combined	.242	.046	.304	.011	.247	.041	.240	.049
College Algebra	.172	.370	.352	.056	.360	.051	.353	.060
Statistics	.311	.054	.282	.081	.151	.358	.113	.492

Shifting attention to demographic characteristics, this study examined whether a student's prior online, prior college-level math, or prior online math experience correlated to any other demographic, academic success or sense of community measures (see Tables 13 and 14). Looking at all courses combined, there was a small negative correlation between prior math experience and Post-Pre CCS (p = .042, r = -.245). Students with no prior college-level math history had greater gains in sense of community. Similarly, in the College Algebra course, there was a small negative correlation between prior online math experience and Post-Pre CCS (p = .097, r = -.309). College Algebra students with no prior online math experience had greater gains in sense of community. This could possibly indicate that students without any prior online math experience were more susceptible to a greater sense of community because they had nothing to compare it to in previous math courses. In all courses combined, there was a positive relationship between prior college-level math history and prior online experience (p = .014, r = .293), implying that students who have taken college-level math before are also likely to have taken an online course before. Since many community college students don't reach college-level math until later in their academic career, it seems probable that they may have taken at least one online course by then.

When examining whether prior experience might have a relationship with academic measures (formative, summative, midterm and final exam scores), there are no correlations when considering all courses combined. However, within the individual subjects, there is a small negative correlation between prior online math experience and midterm score (p = .082, r = -.282) in the Statistic course, and a small negative correlation between prior online math experience and final exam score in Statistics (p = .017, r = -.379) and both courses combined (p = .052, r = -.235). Consequently, for those participants taking Statistics, prior online math experience implied lower midterm and final exam scores. This seems counter-intuitive as one might expect students with prior math or online experience to do better in the subsequent course. It is important to remember, however, that prior experience in a math or online course does not imply that the experience was successful. These students may be repeating bad habits, poor study skills, or other unsuccessful behaviors that result in lower exam scores.

Table 13

Correlation Matrix between Prior Math Experience, Post-Pre CCS and Prior Online Experience by Course

	Post-Pre CCS		Prior Online Experience	
Prior Math Experience	*r*	*p*	*r*	*p*
Combined	-.245	.042	.293	.014
College Algebra	-.357	.053	.351	.057
Statistics	-.186	.258	.240	.141

Table 14

Correlation Matrix between Prior Online Math Experience, Post-Pre CCS, Midterm and Final Exam Scores by Course

	Post-Pre CCS		Midterm Exam		Final Exam	
Prior Online Math Experience	*r*	*p*	*r*	*p*	*r*	*p*
Combined	-.163	.180	-.153	.209	-.235	.052
College Algebra	-.309	.097	-.022	.909	-.096	.612
Statistics	-.021	.897	-.282	.082	-.379	.017

The only significant relationship that student age had in all courses combined was a small positive correlation with prior math experience ($p = .021$, $r = .279$). It makes sense that the older the student, the more likely they would have prior college-level math experience. There were no other significant correlations with age in the Statistics course, but College Algebra had a few relationships. There was a small positive correlation between age and midterm exam ($p = .068$, $r = .338$), final exam ($p = .231$, $r = .225$), and summative score ($p = .109$, $r = .298$) in College Algebra. Older students in College Algebra had higher midterm exam, final exam and summative scores (see Table 15).

Table 15

Correlation Matrix between Age, Prior Math, Midterm, Final Exam and Summative Scores by Course

	Prior Math		Midterm		Final Exam		Summative	
Age	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Combined	.279	.021	.163	.185	.050	.685	.137	.265
College Algebra	.261	.163	.338	.068	.225	.231	.298	.109
Statistics	.298	.069	-.042	.801	-.147	.378	-.026	.877

Only College Algebra had any slightly positive correlations relative to gender. Gender had a small positive correlation with Post-Pre CCS ($p = .277$, $r = .205$) and midterm exam score ($p = .241$, $r = .221$) with a small negative correlation between gender and age ($p = .046$, $r = -.367$). Thus, male College Algebra students had greater growth in sense of community and higher midterm exam scores, while older students in College Algebra were more likely to be female (see Table 16).

Table 16

Correlation Matrix between Gender, Post-Pre CCS, Midterm and Age by Course

	Post-Pre CCS		Midterm		Age	
Gender	*r*	*p*	*r*	*p*	*r*	*p*
Combined	.092	.454	.155	.202	-.064	.604
College Algebra	.205	.277	.221	.241	-.367	.046
Statistics	-.005	.976	.208	.205	.167	.328

Overall, employment status had a small negative correlation with Post-Pre CCS in all courses combined ($p = .026$, $r = -.268$), with a medium-sized negative correlation in Statistics alone ($p < .001$, $r = -.536$). Students who worked more than 20 hours per week had a weaker sense of community. In the College Algebra course, employment status was positively correlated with formative ($p = .228$, $r = .227$) summative ($p = .214$, $r = .234$) and final exam ($p = .121$, $r = .289$) scores. Counter to what might be expected, students who worked more than 20 hours per week were more prone to score higher on their homework, final exam and overall course grade. It is interesting to note that in the Statistics course each of these relationships was the exact opposite, showing a small negative correlation between employment status and formative (p = .068 r = -.295), summative (p = .137, r = -.242), and final exam (p = .328, r = -.161) scores (see Table 17). This may be a factor of small sample sizes and/or evidence of preexisting differences between students in each course.

Table 17

Correlation Matrix between Employment Status, Post-Pre CCS, Formative, Summative and Final Exam Scores by Course

	Post-Pre CCS		Formative		Summative		Final Exam	
Employment Status	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Combined	-.268	.026	-.076	.536	-.048	.696	.043	.728
College Algebra	.042	.824	.227	.228	.234	.214	.289	.121
Statistics	-.536	<.001	-.295	.068	-.242	.137	-.161	.328

Students in both the control and treatment sections were required to make discussion board posts periodically throughout the semester as part of their course grade. Students in the treatment section were also awarded points for attending the Adobe Connect sessions each week. This study explored whether participation on the discussion board and attendance in the Adobe Connect sessions correlated with academic success, sense of community and demographic measures. As expected, in all courses combined, the percentage earned through discussion board postings was positively correlated with formative ($p = .013$, $r = .299$), summative ($p < .001$, $r = .461$), midterm ($p = .005$, $r = .332$) and final exam ($p = .091$, $r = .205$) scores (see Table 18). Students who posted regularly to the discussion board scored higher throughout the course. Likewise, attendance at Adobe Connect sessions was positively correlated with formative ($p = .037$, $r = .353$) and summative scores ($p = .019$, $r = .393$), as well as with discussion board posts ($p = .049$, $r = .335$). Statistics students also showed a medium positive correlation between Adobe Connect attendance and midterm ($p = .015$, $r = .536$) and final exam ($p = .011$, $r = .555$) scores (see Table 19). As one might predict, participation in the synchronous group work sessions correlated with higher homework, midterm, final exam and summative scores. Students who attended the Adobe Connect sessions were also more likely to regularly post to the discussion board ($p = .049$, $r = .335$) in both courses combined. Therefore, participation in the synchronous component was positively correlated with participation in the asynchronous component of the course.

Table 18

Correlation Matrix between Discussion Board Posts Percentage and Academic Measures by Course

	Formative		Summative		Midterm		Final Exam	
Discussion Board Posts %	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Combined	.299	.013	.461	<.001	.332	.005	.205	.091
College Algebra	.349	.058	.302	.105	.142	.455	.083	.662
Statistics	.570	<.001	.589	<.001	.124	.454	.461	.003

Table 19

Correlation Matrix between Adobe Connect Attendance, Academic Measures and Discussion Board Posts by Course

	Formative		Summative		Midterm		Final Exam		Discussion Board Posts	
Adobe Connect Attendance	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Combined	.353	.037	.393	.019	.096	.585	.178	.308	.335	.049
College Algebra	.417	.122	.224	.423	.057	.841	-.056	.842	.320	.245
Statistics	.314	.177	.655	.002	.536	.015	.555	.011	.339	.144

A final comparison was made between participation on the discussion board and attendance in the Adobe Connect sessions with demographic characteristics (see Table 20). A small negative correlation in all courses was found between Adobe Connect attendance and prior online experience (p = .176, r = -.234). Students with no prior online experience were a little more likely to attend Adobe Connect sessions. This might indicate that students with less online experience either just accepted the expectation that the synchronous sessions were part of the online course and therefore attended regularly, or they needed or wanted the Adobe Connect sessions to enhance their learning. In the Statistics course only, a small positive correlation between attendance and gender (p = .272, r = .258) was found, suggesting that Statistics students with good attendance were male. In the College Algebra course alone, students with prior college-level math experience were slightly more likely to have better Adobe Connect attendance (p = .401, r = .234).

Meanwhile, there were no overall correlations between frequency of discussion board postings and demographics in all courses, however, College Algebra demonstrated a small positive correlation between discussion board post percentage and prior online (p = .218, r = .232), prior online math (p = .045, r = .368), and prior math experience (p = .183, r = .250), as well as with age (p = .055, r = .354). Hence, College Algebra students with prior online, college-level math, and online math experience were more apt to post to the discussion board throughout the semester. In addition, older College Algebra students had higher discussion board grades. Statistics students also had a small positive correlation between discussion board posts and prior online experience (p = .095, r = .271), but a negative correlation between discussion board posts and employment status (p = .188, r = -.215). Therefore, Statistics participants with prior online experience had higher discussion board grades, perhaps because they were used to the expectation that online students must post regularly in an online class. Unsurprisingly, Statistics students who work more hours per week had lower discussion board post grades (refer to Table 21).

Table 20

Correlation Matrix between Adobe Connect Attendance, Prior Online, Prior Math and Gender by Course

	Prior Online		Prior Math		Gender	
Adobe Connect Attendance	*r*	*p*	*r*	*p*	*r*	*p*
Combined	-.234	.176	.102	.559	.178	.305
College Algebra	-.317	.250	.234	.401	.158	.575
Statistics	-.148	.533	-.050	.833	.258	.272

Table 21

Correlation Matrix between Discussion Board Post Percentage and Demographics by Course

	Prior Online		Prior Online Math		Prior Math		Age		Employment Status	
Discussion Board Post %	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Combined	.124	.312	.137	.262	-.036	.770	.147	.232	-.166	.173
College Algebra	.232	.218	.368	.045	.250	.183	.354	.055	-.076	.689
Statistics	.271	.095	.008	.959	-.180	.272	-.122	.467	-.215	.188

In conclusion, hypotheses 4 and 5 were marginally supported with small positive correlations existing between sense of community and formative and summative scores. Small positive correlations between sense of community and midterm and final exam scores were also demonstrated. Furthermore, there were a variety of minor correlations between demographics, sense of community and academic success measures.

In addition to the quantitative course data collected, the end-of-semester survey given to treatment section participants included open-ended questions about the student's experience with the synchronous group work sessions (see Appendix C). A similar questionnaire was given to the two instructors as well (see Appendix E). This allowed for some qualitative feedback from both participants and instructors. Almost every treatment participant responded to the questionnaire. The free responses from these survey questions were coded to establish themes and response frequencies for these themes were tallied.

Participant Feedback

What features of the synchronous group work sessions helped you to learn? A total of 34 (out of 35 possible) responses to this question were recorded by participants, 19 by Statistics students and 15 by College Algebra students (see Figure 7). The major themes reported by participants included the benefits of talking through problems with other students to help their understanding (n = 18), collaborating and working in groups (n = 16), and being able to work with and ask their instructor questions (n = 9). Participants appreciated breaking into small groups where they felt more comfortable asking questions, sharing perspectives on how to solve problems, and being able to ask their instructor a question immediately. One participant commented that the synchronous group work sessions provided the "ability to work with [the] professor/students which is not usually the case in other online classes." Another student acknowledged that "being able to see how other students solved problems helped me to better understand different ways to approach a problem."

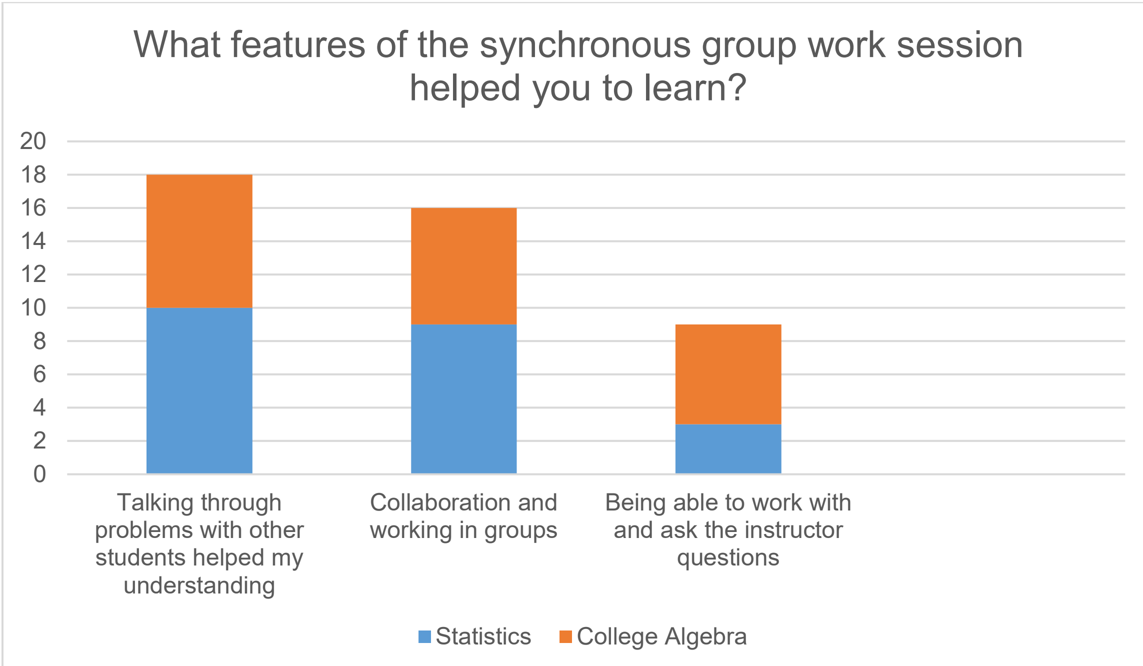

Figure 7. Themes to participant responses to end-of-semester survey question, "What features of the synchronous group work sessions helped you to learn?" (N = 34).

What features of the synchronous group work sessions made it difficult for you to learn? Eleven participants (of 32 responses total) claimed no difficulties with the synchronous group work sessions and found all the features "very helpful and easy to learn with" (see Figure 8). Meanwhile, six participants reported technical issues ranging from being locked out, slow loading pages, difficulty hearing people talk, and challenges with writing problems online without a touch screen computer. The prescribed times of the synchronous sessions provided a hardship for some students (n = 6). "I take online classes to work around my schedule. Having to adhere to a time makes it difficult to be present." A few group issues (n = 4) were described, including lack of participation, students not willing to ask for help, or whole groups that were struggling with the material. Two students also commented on the timing of the material being covered in the groupwork sessions. For one student, the group work sessions were obviously more difficult when the content was ahead of where s/he was on the homework, though this does not seem to be the fault of the sessions. Another student commented that "[t]he group problems were mostly done by students ahead of time and not during class so a lot of times I wasn't learning." The instructors confirmed that several students did complete the group work problems ahead of time, in preparation for the synchronous session.

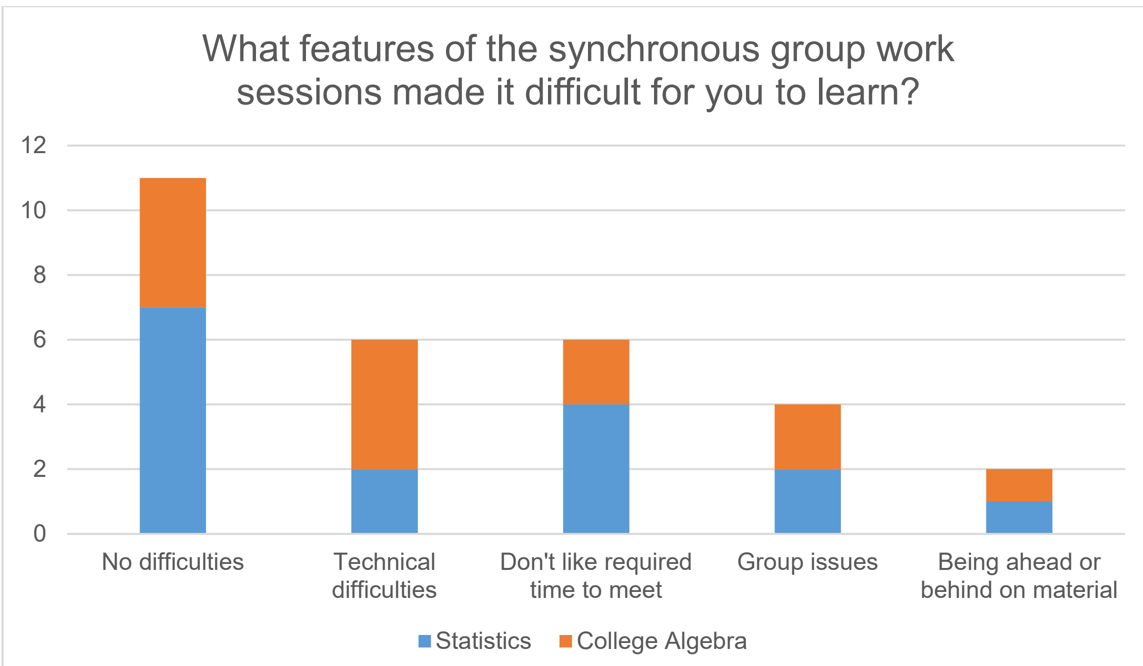

Figure 8. Themes to participant responses to end-of-semester survey question, "What features of the synchronous group work sessions made it difficult for you to learn?" (N = 32).

Did you feel a greater connection to your classmates as a result of using the synchronous group work sessions? Why or why not? More than half (59%) of the free responses to this question affirmed that the participants did feel a greater connection to their classmates as a result of the synchronous sessions (see Figure 9). "Yes, I felt a greater connection to my classmates as a result of using the group work sessions. Hearing their voices and seeing them work made me feel more connected to them by 1) letting me know they exist, and 2) having a more personal relationship with them." Ten out of the 32 comments (31%) expressed no greater sense of connection. "No, it's always harder to establish a connection to other classmates in an online setting." One student acknowledged a slight sense of connection saying, "We interacted and doodle[d] but without face to face it was difficult to connect meaningfully. I did feel more of a general connection to the 'class' however because of the sessions." Both instructors professed a better sense of connection with their treatment students, which was confirmed by one participant. "I think [the synchronous group work sessions] gave me a stronger connection with a few classmates and especially our instructor. So in the end it was probably good." As evident in Figure 9 below, Statistics students were about evenly split in their sense of connection, while College Algebra students felt a greater sense of community with their classmates. This reinforces the quantitative results that showed larger gains in Post-Pre CCS in the College Algebra course, but not so much in Statistics.

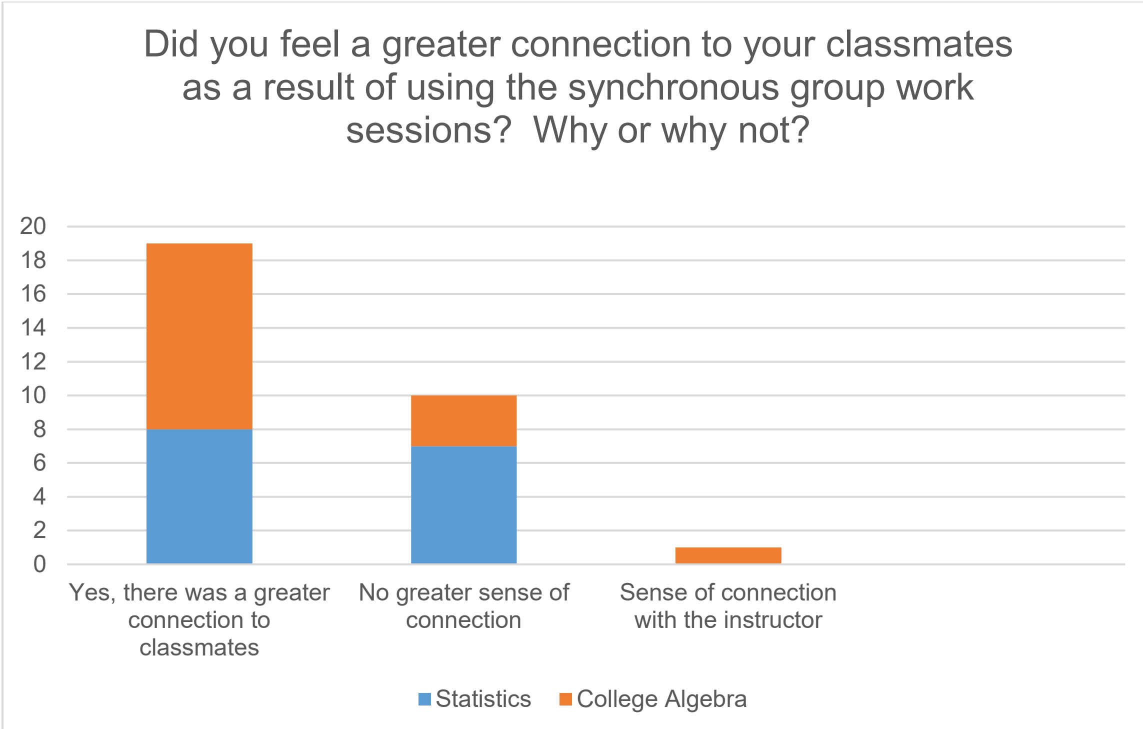

Figure 9. Themes to participant responses to end-of-semester survey question, "What features of the synchronous group work sessions made it difficult for you to learn?" (N = 32).

Instructor Feedback

The instructors were given an end-of-semester survey to fill out. In addition, they met with the researcher for a final debrief session after classes were completed. Occasional check in emails were shared throughout the semester to assess progress and address any issues or questions. Themes for the final instructor questionnaire and debrief responses were coded.

What features of the synchronous group work sessions helped you in your teaching? Both instructors felt that the synchronous group work sessions provided greater interaction with their students and also among their students. In addition, the sessions "helped me answer questions in an efficient way so that the whole group would communicate. They also allowed students to work with each other and make some connections that they wouldn't have had otherwise." Another benefit was the ability to communicate important concepts and reminders to students, and to hit harder the material that students typically struggle with.

What features of the synchronous group work sessions were a challenge? There were a variety of challenges, though all were to be expected. Poor attendance, especially towards the end of the semester made for small groups. One instructor commented, "I also didn't seem to reach the students that might have needed the connection the most. Those students just didn't attend." There were a few technical issues including the occasional slow network that led to glitches and the instructor's voice going in and out. Rarely, a student would get bumped out of the system. However, both instructors felt the technical "issues were minimal and fairly easy to overcome." Of course, scheduling was an obstacle for students, and instructors felt some guilt in requiring online students to attend synchronously. Another frustration was the lack of participation during the sessions. "It was also hard to manage the group work so that everyone was working and contributing. Sometimes one student seemed to do all the work, and some students didn't seem to contribute too much."

Did you feel a greater connection to your students as a result of using the synchronous group work sessions? Why or why not? Above all, both instructors described a much greater connection with their students. "I knew them better as people." One instructor observed, "We had a chance to talk and connect about other topics and communicate about extra help that was needed. In many ways, that was the best part of the sessions – it made it feel closer to a traditional class for me." The sessions also afforded a better insight into what material students were struggling with, so the instructors had a better sense of the students and their understanding of the content. Moreover, the group work provided the opportunity to make connections with other students. "There were times that groups would finish the group work early. Many times they would mute their mics and just hang out until after the session was over, but other times I would go back into the room and they would be laughing and having a conversation with each other." The instructors felt that students received the synchronous sessions positively. Students admitted their appreciation for the sessions on more than one occasion and felt like they benefited from the experience. "Even people who knew what they were doing came to the session and felt they could benefit from explaining to others and talking about it. It was helpful to them."

Chapter V – Discussion

The population of community college students taking mathematics online is a unique group that is frequently underserved and unsuccessful (Bailey et al., 2010). Many community college students typically come to school underprepared and overextended, with greater risk factors and responsibilities than typical four-year students (AACC, 2017; Attewell et al., 2006; Bailey et al., 2010). Online math students in particular struggle to succeed in classes with low pass rates, minimal engagement, and no connection. These students need the efforts of faculty, administration, and institutions to provide better online pedagogy that will increase interaction, offer collaboration, and support a community of learning. The purpose of this study was to determine the impact of embedded synchronous group work sessions in online college-level math courses. It was anticipated that a synchronous component would increase student academic success while also improving student sense of community.

Summary of Findings

This study took place within two online college-level math courses across two community colleges. One instructor taught two sections of Statistics, and another instructor taught two sections of College Algebra. The control section in each course was taught as a normal asynchronous online course, while the treatment section added required weekly synchronous group work sessions. A total of 69 students participated in the study, 39 from Statistics (20 in the treatment section, 19 in the control) and 30 from College Algebra (15 students in each section). It was hypothesized that the treatment of synchronous group work sessions would increase students' formative and summative scores while also boosting students' sense of community. Unfortunately, there was no significant positive effect of the synchronous group work sessions on formative, summative, midterm or final exam scores. In fact, contrary to what was expected, treatment had a medium-sized effect on formative scores in the negative direction. Treatment students had homework scores that were on average an entire grade lower than control students, though there was wide variability in scores. Only treatment average midterm exam scores were higher, but not significantly. There was also no significant difference as a result of the synchronous sessions in sense of community, though treatment did have a small effect on increasing sense of community in both courses. There was a much greater impact on sense of community due to treatment within College Algebra, with a large effect on the learning subscale in particular.

A small positive correlation existed between sense of community and formative and summative scores among all courses. A variety of minor correlations occurred between demographic characteristics and formative, summative, and sense of community scores. Of note, there was a small negative correlation between prior math experience and sense of community. Students with no prior math experience had more positive gains in sense of community. In addition, students working more than 20 hours per week had less growth in their sense of community. Participants with no online experience had statistically greater attendance in the Adobe Connect sessions. Moreover, greater attendance in the Adobe Connect sessions had a small positive correlation with higher grades on the discussion board, suggesting that the synchronous component may have boosted asynchronous engagement for students. This agrees with Giesbers, Rienties, Tempelaar, and Gijselaers (2013), who showed that participation in synchronous communication positively impacted participation in asynchronous communication.

Implications

The sample size for this study was quite small. Course enrollment was not completely full at the beginning of the semester, and as is typical in community college courses, many students withdrew from the course throughout the semester, diminishing numbers further. In addition, several students were under 18 years of age due to the statewide post-secondary enrollment option that allows high school students to concurrently enroll in college-level courses and thus were ineligible for the study. All of these factors worked to shrink the sample size of the study. Although the small sample makes generalization impossible, the study can still provide insight despite its limited statistical power.

While participation in synchronous group work sessions did not predict academic success in this study, there was a small effect on sense of community overall, with a more significant effect specifically in College Algebra. One explanation for the greater change in sense of community in College Algebra could be differences in demographics. The control section of College Algebra had a statistically significant larger Pre Learning score on the Classroom Community Scale (CCS), while the treatment section had a higher, though not significantly, Pre Connect score on the CCS. These discrepancies were much smaller in Statistics. Since the synchronous group work sessions were focused mainly on content, accompanied by some social presence, students in the treatment section may have viewed these sessions as increasing their learning. Alternatively, the control section started with a higher learning score and did not see any additional intervention to make it grow further. Meanwhile, the social aspect of the sessions may have increased connection even more so in the treatment section, but not for the control since they did not experience this additional social presence. In fact, both connectedness and learning decreased slightly for the control, while both increased for the treatment section of College Algebra. Why did this not happen in the Statistics course? While it is impossible to know for sure, the College Algebra treatment section reported more positive qualitative feedback regarding a greater sense of connection with each other and the instructor, more so than what was expressed by Statistics students. Conceivably, the College Algebra instructor may have been able to establish a better rapport or encourage greater connection than the Statistics instructor. Regardless, these students felt better able to connect with their instructor and fellow peers and valued these interactions, as corroborated by Bork & Rucks-Ahidiana (2013) and Jaggars (2014a). Differences in instructor, course content, student receptiveness to the group work sessions, technology issues, and individual student characteristics may have all played a part in explaining why College Algebra students showed greater gains in sense of community compared to Statistics students.

Unlike Jaggars and Xu (2013), greater levels of interpersonal interaction did not correlate with better online student performance in this study. There were no significant effects of the synchronous group work sessions on formative, summative, midterm or final exam scores. The mean average on the midterm was only slightly higher in the treatment sections. This may be due to the earlier and increased exposure these students had to questions similar in style to the midterm through their group work problems, exposure that control students did not have. As the semester progressed, however, these gains failed to materialize on the final exam. What was most surprising was the decreased formative scores in the treatment sections, which were over a letter grade lower with wide variation in scores. Indeed, the treatment sections consistently had low outlier scores on homework, midterm and final exam, and summative scores. These worked to regularly drag down the average for the class. The variance of the formative scores in the treatment section was notably larger than the variance among scores in the control section. This wide variability occurred in both Statistics and College Algebra. These low scores could be due to poor study habits, lower ability, life circumstances, or other student idiosyncrasies. With sample sizes being so small, the data were more significantly manipulated by these extremely low scores than a course with more students. Moreover, the Statistics instructor felt that her treatment section contained "weaker" students than her control section.

In an effort to measure whether one section of students was weaker at the start than another, student assessment test and placement history was considered. However, with the advent of multiple measures, placement testing has become quite complicated. It is a challenge to try and quantify who is a "better" student given the variety of placement tests and scores allowed and the lack of confidence in a standardized test's ability to successfully predict appropriate placement. Therefore, it is nearly impossible to quantitatively identify whether a class consists of stronger or weaker students from the start. However, based on many years of experience and her sense of her students, the Statistic instructor felt that her treatment section of students was weaker, needier, and required more help than her control section. If true, it may help explain the lack of higher formative and summative scores due to treatment because these students perhaps started from a deficit and were less likely to be successful.

Demographic variables were not strongly predictive of academic success or sense of community. Employment status had a greater effect and negative correlation with Post-Pre CCS, formative, summative and final exam scores. This resonates with Shea et al. (2006), who found that students with full time employment had a weaker sense of community than those working part time or not at all. Interestingly, the College Algebra course had small positive correlations compared to Statistics' larger negative correlations involving employment status. With a similar majority demographic of working students, Statistics students working more than 20 hours per week were not as receptive to sense of community as working students in College Algebra. This may be another underlying factor that explains why the Statistics students did not feel the effect of treatment as strongly as the College Algebra students.

How does this study reflect upon the theories of a Community of Inquiry, transactional distance, and connectivism? It was clear from the beginning of this study that teaching presence (and structure) would be necessary for the synchronous sessions to run smoothly with greater student interaction. The instructors needed to actively engage students to get them to participate in both the large and small group discussions. As corroborated by Garrison and Cleveland-Innes (2005), students were less likely to initiate discussion and construct knowledge without this leadership role. The sessions provided another option for developing social presence and increasing dialogue, not just between students but also between students and the teacher. Though the instructors in this study did not focus much on developing learning presence, the synchronous sessions offer a potential stage for integrating metacognitive strategies. Qualitatively through student responses, there appeared to be better understanding of course content (cognitive presence) during the sessions, though this was not measurable in the formative and summative scores of students. The synchronous group work sessions also provided another learning community, or node, to further add to a student's learning network as proposed in the theory of Connectivism. Students admitted to learning from each other. This cyclical learning process is a cornerstone of connectivism, while simultaneously promoting discussion, variety of perspective and group collaboration (Rank, 2018). Despite the inability to measure increased academic success and community, there seems to be little harm in adding these synchronous sessions in some capacity to online courses.

Strengths and Limitations

A major strength of this study was the use of web conferencing technology to enable group work in online math courses at community colleges. Some studies have investigated the use of web conferencing technology but only for the purpose of providing additional lectures (Olson & McCracken, 2015). Others have only allowed students to chat with one another (Duncan, Kenworthy & McNamara, 2012; Hrastinski, 2008; Olson & McCracken, 2015), not utilizing the full capability of audio and video. The benefits of group work have been well-documented (Gillies & Ashman, 2003; Hassanien, 2007; Johnson & Johnson 2003; Sharan, 1980; Slavin, 1980), but there is little documenting the use of online group work, especially that enabled by web conferencing technology. Even more limited is the use of web conferencing technology in online math courses (Mayer et al., 2017; Tonsmann, 2014). Moreover, few studies focus their attention on the population of community college students, instead concentrating on four-year undergraduate or graduate students (Falloon, 2011; Rockinson-Szapkiw & Wendt, 2015, Strang, 2013). Two-year community college students tend to be more nontraditional, less academically prepared and face more challenges and risk factors (AACC, 2017; Attewell et al., 2006; Bailey et al., 2010).

Another strength of this study is that it measured the effect of synchronous sessions on actual academic success, rather than just perceived learning and satisfaction, like Falloon (2011) and He and Huang (2017). Student success is primarily determined by grades, therefore a treatment will be most effective when it helps students pass their classes. Thus, a major focus of this study was on the effect of synchronous group work on formative and summative grades.

Finally, one more unique strength of this study was its use of the whiteboard tool in Adobe Connect in helping facilitate communication in a math course, which requires special symbols, notation and graphs. Other subject areas utilize web conferencing to enhance their course, for example the language courses of Lindgren and Leblanc (2013) and Wang and Chen (2007), but few need or use the whiteboard tool. Online math instructors continue to seek technology that will allow two-way communication with their students that maintains the flexibility of a chalk board and allows students to contribute their solutions and mathematical thinking (Smith & Ferguson, 2004). This study chose a technology that would allow for that flexibility.

The greatest limitation of this study was the small sample size. With only 69 total participants, and individual sections consisting of only 15-20 students, the data became more susceptible to outliers and the ability to generalize was weakened. In addition, the study took place in only two college-level math courses at Midwestern suburban community colleges. These introductory college-level courses do not represent all the pathways and curriculum of every community college student. This population may also lack the diversity of other schools that are more urban or more competitive.

Another limitation of this study was that only two instructors participated in the study and taught two different courses. Comparison of grades was complicated by different grading schemes, activities and assessments. This study could also not completely control the activities, questioning style and facilitation of the synchronous group work sessions unique to each instructor. Personal style undoubtedly affected students' interactions, sense of community and learning. This could be viewed as a strength of the design of the study, but with such a small sample size and only two instructors involved, it ended up being a limitation. The Statistics and College Algebra courses often had conflicting results, which may have been due to instructor or student differences.

Another important limitation of the study was that the instructors spent little, if any, time on learning presence. Given that most students take Statistics or College Algebra towards the end of their community college tenure, both instructors felt that their students were already well equipped with study skills and success strategies, and therefore, learning presence did not need additional reinforcing. The results of this study might have been strengthened, and students may have been more successful if lessons on learning presence, self-help, growth mindset and strategies for dealing with math and test anxiety were incorporated into the synchronous sessions.

Not using webcams despite the technology available was another limitation of this study. Adobe Connect offers the ability to display visual cues via webcams. One instructor always turned on her webcam at the start of every session, but the other instructor did not use the webcam after the first few sessions because connectivity issues were slowing things down. No students chose to enable their webcams during the sessions. Without the webcams, there was a lack of visual feedback to interpret students' understanding via body language and visual cues (Cornelius, 2014; Ng, 2007). Silences were often awkward because it was difficult to know if students were being quiet because they agreed, were confused or couldn't hear. Adobe Connect definitely offered a richer, more natural means of communicating with students compared to the typical asynchronous online discussion board, yet still lacked a two-way visual connection that would have enhanced visual cues for understanding because students (and one instructor) did not make full use of the technology. This deficiency may have inhibited student success and sense of community while simultaneously confirming the media richness and naturalness theories.

A final limitation of this study was the possibility of selection bias since students self-selected which online section to take based on communication prior to the start of the semester. During the registration period, the Statistics course posted the attendance requirement for the weekly synchronous sessions. While not all students read these course notes, some students may have and used them to make a choice for course registration. Both course instructors also sent out email communication two weeks before classes started to inform students about the synchronous attendance requirement, so that students would be aware of upcoming expectations and could adjust their registration if the requirements were not viable for their schedule. Both instructors noted a small movement of students between sections during this time. Those students who chose to stick with the treatment section may have characteristics unique to their willingness to participate. One instructor felt that her treatment section consisted of weaker students who needed more help than her control section and hypothesized that this may be the reason that these students signed up for the additional synchronous sessions. It is impossible to tell what motivated this choice. Any number of reasons including prior experience in online courses, fear of math, scheduling issues, confidence, sociability, and technology concerns may have worked to create selection bias.

Ultimately, the results of this study suggest that treatment and control students were not equivalent due to student differences. Small sample size can be overcome with additional, larger studies. Eliminating inequivalence of groups would require better pretesting and sampling, not the sample of convenience that was used in this study.

Recommendations for Further Research

This study should be replicated in equivalent introductory courses at two-year schools with larger sample sizes and a variety of instructors so that more data can be gathered. Interventions that might increase success in these typical gatekeeper courses could be beneficial to students and institutions alike. Moreover, further research should explore the use of synchronous group work sessions in developmental math courses, especially since the students in these courses would more likely benefit from additional support, communication and interaction (Boylan, 2011; Cafarella, 2014). The use of synchronous sessions has been attempted in some language courses (Lindgren & Leblanc, 2013), but additional research should explore its use in other disciplines, including other STEM fields.

Despite training with Adobe Connect and self-reported comfort with the technology, both students and instructors in this study experienced minor technical difficulties that may have hindered the sense of community that those students might otherwise have experienced. To limit variability between the treatment and control sections, the same instructor was assigned to both. The results reported here may be idiosyncratic to these instructors. It would be beneficial to conduct further research with additional instructors and courses, and perhaps study the experience of students and instructors using this technology for the second or third time.

Given that the intervention and demographic variables were not predictive of academic success and/or community, other factors may be involved. Future research should examine whether course discipline and the level of course difficulty influences the impact of the intervention on academic success and community. Community college students' success and sense of community may also depend on individual student characteristics, such as learning presence, changes in life circumstances, or "grit" (Dweck, 2008; Shea et al., 2012). More research around these non-cognitive traits would allow institutions and instructors to target more effective interventions to those college students at risk for dropping out or failing. In addition, research that focused on innovations that develop students' time management and independent learning skills, which are critical to success in online learning (Bambara et al., 2009; Bork & Rucks-Ahidiana, 2013; Shea et al., 2012), could benefit students, instructors, and institutions.

Students had one hour each week in the synchronous group work sessions. Of this one hour, 30-40 minutes were typically spent working in random small groups. While most groups were able to work through their problems to completion in the allotted time, it was difficult to reach full closure on some questions. This restricted time did not always allow enough time for off-task camaraderie and relationship-building. Further research might extend the time of these synchronous group work sessions to allow for more community building, group cohesion, and extended time to work on problems. Even adding an extra half hour per session could potentially allow for more bonding, productivity, and closure. Further research might also consider measuring student engagement in these synchronous sessions, and over time, to see how this affects their sense of community and academic success.

By choice, students opted to not turn on their own webcams during the synchronous sessions. This may have been due to shyness, an unwillingness to let others see into their environment, or even the desire to be able to step away, unseen, from the session temporarily. The instructors didn't push the issue of using personal webcams because they were afraid of connectivity issues and didn't want to strain the system. Webcams require high connection speeds. Further research, once more reliable bandwidth and technology is available, could explore the effect that using webcams for everyone in the classroom, and not just for the instructor, could impact sense of community and academic success due to increased visual cues.

The courses involved in this study were delivered using the learning management system Desire to Learn (D2L) Brightspace and the synchronous sessions utilized Adobe Connect. Using different technology may have different results. Technological issues may have affected the quality of the synchronous sessions, especially the difficulty in writing on the whiteboard screen. Despite the power of the technology, there remained a certain awkwardness involved with using Adobe Connect in a math class. Additional research could explore whether utilizing a different learning management system and/or web conferencing technology impacts student success and community. With the neverending evolution of technology, this may be an interminable task. Indeed, during the course of writing this dissertation, the state system overseeing both participating community colleges decided to switch from Adobe Connect to Zoom as their web conferencing provider. All colleges and instructors face these constant changes in technology, thus their pedagogy and instructional interventions need to withstand and adapt to chronic upheavals.

Overall, the learning activities, instructor facilitation, course design, and questioning techniques all affected student participation, interaction, community and academic success. While Tallent-Runnels et al. (2006) found group discussions to be shallow with little co-construction and consensus occurring, the instructors in this study reflected that most group discussions were on-task and groups were able to reach the correct answer by the end with some guidance from the teacher. Although there may have been different levels of understanding by individual group members, the group as a whole was typically able to get each group problem correct. The specific tools used in Adobe Connect (i.e., breakouts, polls, and whiteboards) impacted class dynamics. The interactions on the whiteboard and accompanying audio were not recorded and thus, not studied. These audio and visual interactions could be recorded and examined in future research to better measure student interaction and participation as well as instructor engagement strategies. The use of different tools might also be studied to determine their impact on success and community.

This study was only able to measure rudimentary levels of previous online experience and previous college math experience based on student responses. It would be both beneficial and interesting to further research how different student backgrounds (i.e., previous online experience, previous math experience, developmental math experiences, online orientation experience, or lack thereof, and student math mentality) might impact the results of this study and how receptive students are to these synchronous group work sessions based on their background.

Given the lack of a statistically significant difference in student achievement, it is worth considering whether embedding synchronous group work sessions into an online math course is worth the investment of time and energy. Though the intervention did not demonstrate significant academic benefit for students, it also did not represent a detriment to student learning. The synchronous component definitely allowed for instructors to gain a better sense of their students, and in turn, for students to acknowledge and learn from each other. For institutions that already support the technology and infrastructure needed to facilitate synchronous interaction, embedding synchronous sessions into online course work may not increase student success, but may still appeal to students and provide a marketing ploy for attracting students to online programs that support a cohort model (Olson & McCracken, 2015). In addition, though no significant difference in sense of community was measured, this was a new experience for most, if not all, of the online students who participated. If synchronous components were to become standard in online programming, it is possible that over time, students and instructors would take more advantage of the opportunity and better develop a sense of community in the online environment. Of course, this assumes that online students are able and willing to attend synchronous sessions at prescribed times. For those who felt pressured to attend, their sense of community could have been negatively impacted by the requirement. It is important to remember that the major appeal of online courses is their flexibility in scheduling. Online students and online instructors have grown to enjoy this freedom, so a synchronous time requirement constrains students and teachers. An institution implementing a synchronous component in its online programming will need to take into consideration the loss of students and the limitations on its faculty due to the time expectations. Overall, the course instructors invested significant time and resources in preparing their classes for these synchronous group work sessions. The community colleges involved already had access to Adobe Connect, however, considerable time was spent prepping course materials, communicating with students, and training with the technology. Faculty and institutions need to decide if this investment is worth continuing if no statistically significant benefits are demonstrated.

Regardless of the results of this study, online learning remains an important opportunity to improve course access and flexibility for college students. The research reviewed in this study suggests that colleges need to offer online courses with equal opportunity for success, and it is necessary that instructors and institutions provide proactive support and high-quality online offerings for students. This study confirms that it is worthwhile to continue investing resources and research into increasing the effectiveness of online learning as there is still much room for improvement. Community college students deserve our full efforts to help them overcome barriers and be successful.

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Appendix A - Classroom Community Scale

(Rovai, 2002b)

(administered using the Qualtrics Survey tool as both a pre-test and post-test)

Directions: Below, you will see a series of statements concerning the math course you are presently taking. Read each statement carefully and choose the statement that comes closest to indicate how you feel about the math course. There are no correct or incorrect responses. If you neither agree nor disagree with a statement or are uncertain, choose neutral (N). Do not spend too much time on any one statement, but give the response that seems to describe how you feel. *Please respond to all items.*

	Strongly agree (SA)	Agree (A)	Neutral (N)	Disagree (D)	Strongly disagree (SD)
1. I feel that students in this course care about each other	(SA)	(A)	(N)	(D)	(SD)
2. I feel that I am encouraged to ask questions	(SA)	(A)	(N)	(D)	(SD)
3. I feel connected to others in this course	(SA)	(A)	(N)	(D)	(SD)
4. I feel that it is hard to get help when I have a question	(SA)	(A)	(N)	(D)	(SD)
5. I do not feel a spirit of community	(SA)	(A)	(N)	(D)	(SD)
6. I feel that I receive timely feedback	(SA)	(A)	(N)	(D)	(SD)
7. I feel that this course is like a family	(SA)	(A)	(N)	(D)	(SD)
8. I feel uneasy exposing gaps in my understanding	(SA)	(A)	(N)	(D)	(SD)
9. I feel isolated in this course	(SA)	(A)	(N)	(D)	(SD)
10. I feel reluctant to speak openly	(SA)	(A)	(N)	(D)	(SD)
11. I trust others in this course	(SA)	(A)	(N)	(D)	(SD)
12. I feel that this course results in only modest learning	(SA)	(A)	(N)	(D)	(SD)
13. I feel that I can rely on others in this course	(SA)	(A)	(N)	(D)	(SD)

14. I feel that other students do not help me learn	(SA)	(A)	(N)	(D)	(SD)
15. I feel that members of this course depend on me	(SA)	(A)	(N)	(D)	(SD)
16. I feel that I am given ample opportunities to learn	(SA)	(A)	(N)	(D)	(SD)
17. I feel uncertain about others in this course	(SA)	(A)	(N)	(D)	(SD)
18. I feel that my educational needs are not being met	(SA)	(A)	(N)	(D)	(SD)
19. I feel confident that others will support me	(SA)	(A)	(N)	(D)	(SD)
20. I feel that this course does not promote a desire to learn	(SA)	(A)	(N)	(D)	(SD)

Appendix B - Classroom Community Scale Scoring Guide

(Rovai, 2002b)

Scoring Scale	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. I feel that students in this course care about each other	4	3	2	1	0
2. I feel that I am encouraged to ask questions	4	3	2	1	0
3. I feel connected to others in this course	4	3	2	1	0
4. I feel that it is hard to get help when I have a question	0	1	2	3	4
5. I do not feel a spirit of community	0	1	2	3	4
6. I feel that I receive timely feedback	4	3	2	1	0
7. I feel that this course is like a family	4	3	2	1	0
8. I feel uneasy exposing gaps in my understanding	0	1	2	3	4
9. I feel isolated in this course	0	1	2	3	4
10. I feel reluctant to speak openly	0	1	2	3	4
11. I trust others in this course	4	3	2	1	0
12. I feel that this course results in only modest learning	0	1	2	3	4
13. I feel that I can rely on others in this course	4	3	2	1	0
14. I feel that other students do not help me learn	0	1	2	3	4
15. I feel that members of this course depend on me	4	3	2	1	0
16. I feel that I am given ample opportunities to learn	4	3	2	1	0
17. I feel uncertain about others in this course	0	1	2	3	4
18. I feel that my educational needs are not being met	0	1	2	3	4
19. I feel confident that others will support me	4	3	2	1	0

20. I feel that this course does not promote a desire to learn	0	1	2	3	4

Note. The connectedness subscale is measured by adding the scores of the odd Classroom Community Scale items (1,3,5, etc.). The learning subscale is measured by adding the scores of the even Classroom Community Scale items (2,4,6, etc.). To obtain the overall Classroom Community Scale score, add the weights of all 20 items. Total raw scores range from a minimum of 0 to a maximum of 80. Subscale raw scores range from a minimum of 0 to a maximum of 40.

Appendix C - Brief Questionnaire for Treatment Group

(administered using the Qualtrics Survey tool)

Brief Questionnaire (to be given at the end of the semester):

Please answer the following questions:

1. What features of the synchronous group work helped you to learn?
2. What features of the synchronous group work made it more difficult for you to learn?
3. Did you feel a greater connection to your classmates as a result of using the synchronous group work sessions? Why or why not?
4. How comfortable did you feel using Adobe Connect?

1	2	3	4	5
Very Uncomfortable				Very Comfortable

5. Had you taken an online course in college prior to this one? Yes or No
6. Had you taken an online math course in college prior to this one? Yes or No
7. Have you taken any math courses in college prior to this course? Yes or No
8. How old are you? (fill in the blank)
9. What is your gender? Male Female Other
10. What is your employment status?

    Work less than or equal to 20 hours per week Work more than 20 hours per week
11. Where do you currently live?

    Within the Twin-Cities metro area

    Outside of the metro area but in Minnesota or Wisconsin

    Out of state (not in Minnesota or Wisconsin)

Appendix D - Brief Questionnaire for Control Group

(administered using the Qualtrics Survey tool)

Brief Questionnaire (to be given at the end of the semester):

Please answer the following questions:

1. Had you taken an online course in college prior to this one? Yes or No
2. Had you taken an online math course in college prior to this one? Yes or No
3. Have you taken any math courses in college prior to this course? Yes or No
4. How old are you? (fill in the blank)
5. What is your gender? Male Female Other
6. What is your employment status?

   Work less than or equal to 20 hours per week Work more than 20 hours per week
7. Where do you currently live?

   Within the Twin-Cities metro area

   Outside of the metro area but in Minnesota or Wisconsin

   Out of state (not in Minnesota or Wisconsin)

Appendix E - Instructor Survey Questions

Instructor Survey (to be given at the end of the semester):

Please answer the following questions:

1. What features of the synchronous group work sessions helped you in your teaching?

2. What features of the synchronous group work sessions were a challenge?

3. Did you feel a greater connection to your students as a result of using the synchronous group work sessions? Why or why not?

Appendix F - Synchronous Group Work Sessions Participation Rubric

A rubric is given below to show how the Adobe Connect Sessions will be graded on participation.

	Beginning	**Developing**	**Accomplished**
Preparation	Student shows no evidence of knowledge gained by watching video lectures ahead of session. (0 points)	Student shows some evidence of knowledge gained by watching video lectures ahead of session. (2 points)	Student shows evidence of knowledge gained by watching video lectures ahead of session. (4 points)
Collaboration	Student did not work together with group members to accomplish the task, and did not ask questions, provide help or add to the discussion. (0 points)	Student only partly worked with group members to accomplish the task, asked minimal questions, provided little help and did not add much to the discussion. (2 points)	Student worked together with group members to accomplish the task, asking questions, providing help and adding to the discussion. (4 points)
Timeliness	Student did not attend the session. (0 points)	Student was late and/or did not stay for the entire session (1 points)	Student was on time and attended the entire session. (2 points)

Appendix G - Permissions

Re: Permission to use Community of Inquiry and Modes of Interaction in Distance Education Figures in Dissertation Work

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D. Randy Garrison <garrison@ucalgary.ca>
Thu 5/3/2018 8:23 PM

To: Carrie Naughton;

You replied on 5/3/2018 9:59 PM.

Carrie,
You have my permission to reprint the CoI and Modes of Interaction figure for your dissertation.
Best wishes,
DRG

Sent from my iPad

> On May 3, 2018, at 6:41 PM, Carrie Naughton <CNaughton@inverhills.edu> wrote:
>
> Dear Dr. Garrison,
>
>
> I am reaching out to you to request permission to reprint your Community of Inquiry figure (Figure 1 on page 88 from your article "Critical Inquiry in a Text-Based Environment: Computer Conferencing in Higher Education") and your Modes of Interaction in Distance Education figure (Figure 2 from "Learning in a Networked World: New Roles and Responsibilities").
>
> I am a doctoral student in the Educational Leadership program at Minnesota State Mankato. I am in the process of writing my dissertation, a study on the effects of synchronous group work on learning and sense of community in online mathematics courses at community colleges. In my literature review, I will be using the CoI model as a potential framework for my study and will also be exploring different modes of interaction necessary in online learning.
>
>
> Please let me know if you would allow me to reprint your CoI model and Modes of Interaction figure within my own dissertation work. If you have any other questions, please let me know. Thank you for your consideration,
>
>
> Carrie
>